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ABSTRACT

Water is one of the natural resources vital to any agricultural system, This material was developed in support of the Iowa Agricultural Science, Technology and Marketing (ASTM) program, focusing on groundwater educational concepts related to the 1987 Iowa Groundwater Protection Act. This material was designed to assist teachers in providing systematic groundwater instruction for high school students enrolled in ASTM classes. Eight instructional units include: (1) "Recognizing Groundwater Concerns"; (2) "Describing the Water Connection"; (3) "Locating Direct Connections"; (4) "Managing Nitrogen Fertilizers"; (5) "Managing Agricultural Pesticides"; (6) "Managing Underground Tanks and Pipelines"; (7) "Managing Natural Fertilizers"; and (8) "Managing Urban Fertilizers and Pesticides." Each unit includes lesson plans that feature objectives, interest approach, a list of materials needed, and teaching procedures. Additional information is provided by information sheets, activities, visual masters, references, and videos. A glossary is included to assist in learning terms related to groundwater. Also included is a list of careers in which people may use groundwater knowledge and skills. Lists of water testing laboratories, videos related to groundwater, and a list of farmers participating in the 1989 Resourceful Farming Demonstration are appended. The Groundwater Act and a manual for a groundwater flow model are also provided. (YP)

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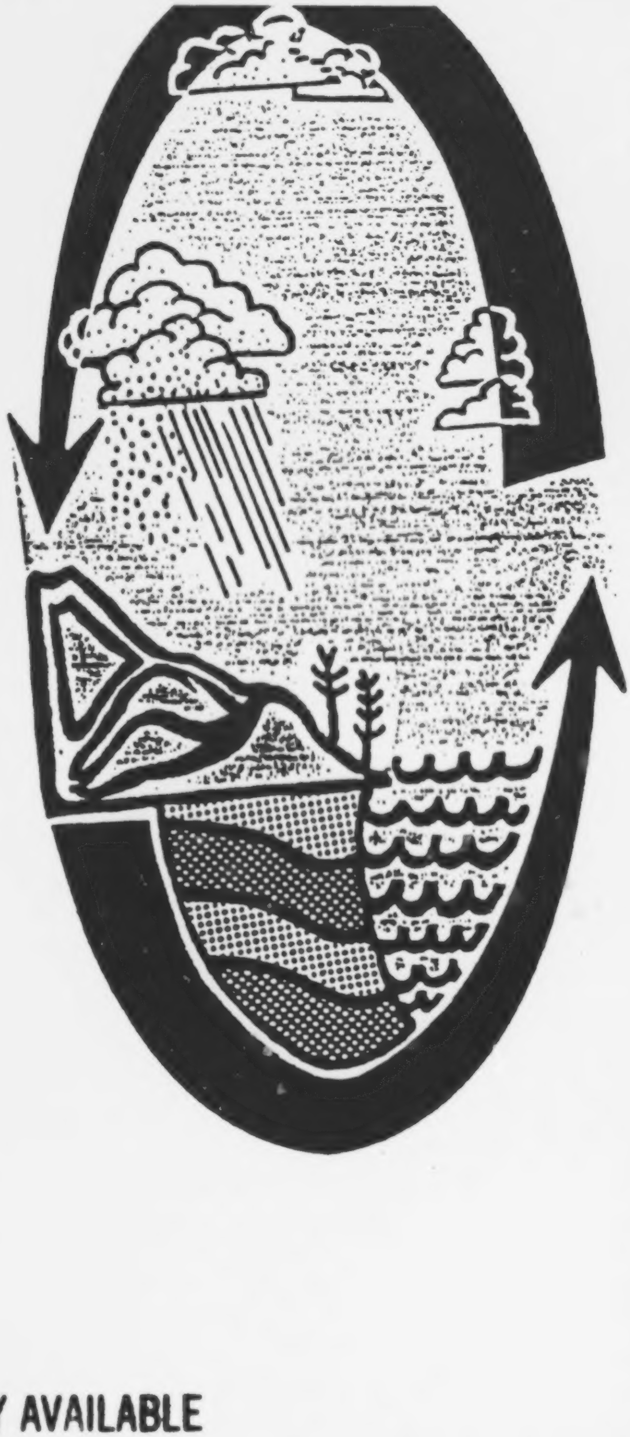
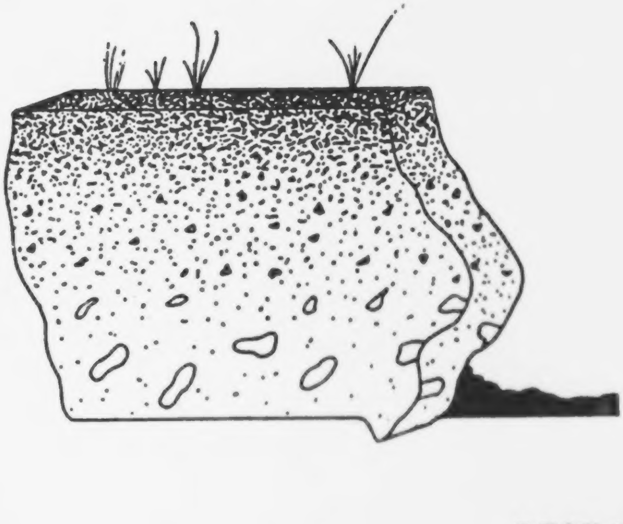
GROUNDWATER PROTECTION THROUGH PREVENTION

A CURRICULUM FOR AGRICULTURAL EDUCATION IN SECONDARY SCHOOLS





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GROUNDWATER PROTECTION THROUGH PREVENTION

A Curriculum

for Agricultural Education in Secondary Schools

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Ordering Directions:

This printed curriculum and the "Groundwater on The Move" and "Operation and Maintenance: The Groundwater Flow Model" videotape (two programs) is available from the Iowa Association for Vocational Instructional Materials Center, 208 Davidson Hall, Iowa State University, Ames, IA 50011. Telephone (515) 294-6673. Cost of the printed material is $15.00, plus shipping. Cost of the videotape is $17.50, plus shipping.

"Seeds of Survival" videotape is available from Filmfair Communications, 10621 Magnolia Blvd., North Hollywood, California 91601. Or call collect (818)-985-0244, Extension 262, attention Ethel Poirier.

"Groundwater and Agricultural Chemicals: Understanding The Issues" videotape is available from members of The American Soybean Association, National Corn Growers Association, or Monsanto Agricultural Company.

Plexiglas Groundwater Flow Models are available from Iowa State University, Student Chapter of The Soil and Water Conservation Society, 2521 Agronomy Building, Iowa State University, Ames, IA 50011.

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Appreciation is expressed to the following individuals for their contribution to the development of these educational materials.

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Funding for support materials including groundwater flow models, videotapes and reference publications, was provided by Monsanto Agricultural Company.

Technical review was made by staff from the following agencies: DNR; SCS; and the Cooperative Extension Service, Iowa State University.

INTRODUCTION

Groundwater is an important natural resource in Iowa. It is important for at least three reasons:

1. Groundwater supplies drinking water for about 80% of all Iowans and for virtually all private rural users.
2. Groundwater contamination can affect the **ecosystems** of plants and animals, because groundwater often recharges lakes and streams.
3. Iowa's **economy** depends on groundwater because three-fourths of the water is used for livestock, irrigation and commercial purposes.

"Protection through prevention" is the basis of Iowa's groundwater protection policy. It is more feasible, more effective, and less expensive to prevent groundwater contamination than to try to clean it up after it has occurred. Many management practices that reduce groundwater contamination also save energy.

The **priority of groundwater issues in Iowa** were outlined in the Iowa Groundwater Protection Strategy and agreed upon by the Iowa Legislature, Department of Natural Resources, and other groups interested in groundwater quality. The strategy was the basis for Iowa's 1987 Groundwater Protection Act, a landmark piece of legislation. Iowa's groundwater issues in priority order include:

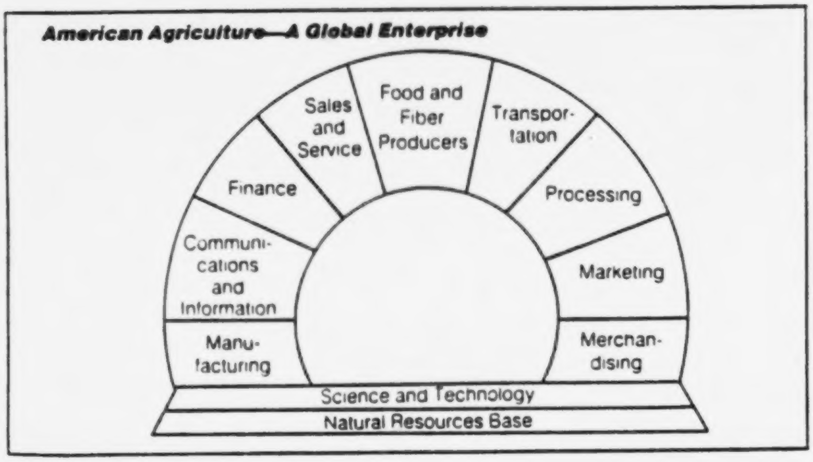
1. Fertilizers and pesticides
2. Abandoned waste sites and landfills
3. Leaking underground storage tanks and handling and transporting hazardous materials
4. Direct paths of contamination (agricultural drainage wells, abandoned wells, and sinkholes)
5. Land-applied wastes and sewage treatment

Agriculture has an important role to play in the protection of groundwater quality. Groundwater Protection through Prevention: A Curriculum for Agricultural Education in Secondary Schools was developed to help people understand the relationships between groundwater quality and agricultural systems.

The materials were designed for use in Agricultural Science, Technology and Marketing (ASTM) classes in Iowa high schools. However, the materials are appropriate for use in other classes in middle, secondary, and post-secondary schools, and with youth and adults in nonformal settings. Every person is affected by the quality of groundwater, and all should be aware of ways to protect this important resource. These materials will help develop this awareness and identify actions needed to protect groundwater quality.

FOREWORD

The United States Department of Agriculture (USDA) model of the agricultural system shown below was used in developing a new Iowa vocational and technical education program in agriculture known as "Agriculture Science, Technology and Marketing" (ASTM). USDA and ASTM programs recognize American agriculture as a global enterprise with nine (9) functions: (1) manufacturing, (2) communications, (3) finance, (4) sales and service, (5) food and fiber producers, (6) transportation, (7) processing, (8) marketing and (9) merchandising. These functions make up the agricultural system and can be depicted as an arch. The arch rests on two vital bases -- natural resources and science and technology.


American Agriculture—A Global Enterprise
Sales and Service
Food and Fiber Producers
Transportation
Finance
Processing
Communications and Information
Marketing
Manufacturing
Merchandising
Science and Technology
Natural Resources Base

Source: 1986 Yearbook of Agriculture

Water is one of the natural resources vital to any agricultural system. Knowledge about water is also included in the science and technology that supports the functions in the agricultural industry. In addition to supporting the agricultural industry, groundwater provides 30 percent of the urban population and 97 percent of the rural population in the United States with drinking water. Maintaining the quality of our groundwater is a national, state and local concern.

These educational materials were developed in support of the Iowa ASTM program. They focus on groundwater educational concepts directly related to the 1987 Iowa Groundwater Protection Act. The materials were designed to assist teachers in providing systematic groundwater instruction for high school students enrolled in ASTM classes.

This notebook includes eight (8) instructional units. Each unit includes lesson plans that feature objectives, interest approach, a list of materials needed, and teaching procedures. Concise technical information is provided through accompanying information sheets (INFO), activities (ACT), visual masters (VM), references and two videos.

A glossary is included to assist in learning terms related to groundwater.

Classroom/laboratory instruction suggested in these materials can be expanded through FFA activities and supervised agriculture experience (SAE). Involvement of students in community projects, contests, award programs, and leadership activities related to groundwater concepts and issues can create student interest and enhance learning.

A list of some careers where people may use groundwater knowledges and skills is included. Relating groundwater subject matter to jobs performed by people helps bring reality to the lesson.

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Eldon C. Weber
Soil Conservation Service-
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- Health effects
- Environmental concerns
- Management practices to reduce contamination

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- Reprint from The Iowa Conservationist, "The Groundwater Act, How does It Affect You?"
- Videos Related to Groundwater
- Manual For Groundwater Flow Model
- List of Farmers Participating in the 1989 Resourceful Farming Demonstrations

PREVIEWS OF VIDEOS

27 Min. PREVIEW OF "SEEDS OF SURVIVAL" - 1983

The video follows a Nebraska farm family and their farming neighbors through one year in their lives - from planting through harvest. It shows the farmers trying to cope with three major threats - problems which are inextricably linked to the widespread use of synthetic fertilizers and pesticides. It features one farmer who successfully shifted back to organic farming - not an easy feat. These farmers now face the worst odds for their survival in U. S. history. The video is down-to-earth and well-illustrated by progressive young farmers and their families. The video begins with a patio scene discussing the tremendous destruction caused by a 1982 storm that destroyed crops, washed off chemicals and resulted in topsoil loss. Farmers discuss their economic plight resulting from the present agriculture system, discuss how their fathers and grandfathers did take care of the land, but that the current generation has abandoned crop rotations. They agree that incentives for farms to get bigger and produce higher yields are not the answer.

As you listen to agricultural chemical company representatives at the Husker Harvest Day try to sell chemicals, the featured farmers are saying they make you believe you can't farm without chemicals, one says "I'm almost to the point I was brainwashed". Use of chemicals are more costly to the farmers each year.

The video shows the wife being x-rayed to see if they have arrested the cancer that she has had. The question is asked: could it be related to the agricultural chemicals being used? The farmer admits he needs to use some chemicals. A Nebraska farmer who was one of the largest chemical farmers in the state 16 years ago is featured. He changed to organic farming using rotations, manures, and other biological practices. He spends no money on chemicals, uses no irrigation, and gets top prices for his products. He says diversity of crops spreads out risks and reduces insects. He says it takes 3 to 5 years to make the transition from chemical to organic farming, and at first you can expect lower yields. The video makes a point that USDA, at that time, was not putting resources into sustainable agriculture.

The film ends with the mother, in a cab, driving the tractor with her small child taking a nap, with the statement - "We really don't own the land".

Copies of "Seeds of Survival" were purchased from Filmfair Communications, to be included as a functioning part of this curriculum. The video sets the stage of "urgency" for groundwater education in agriculture to develop needed knowledge, values, and skills among present and future farmers and decision makers. Filmfair Communications agrees to make the video available to users of the curriculum at published rates. All inquiries as to price and availability of the video should be addressed to Filmfair Communications, 10621 Magnolia Boulevard, North Hollywood, California 91601.

18 Min. GROUNDWATER AND AGRICULTURAL CHEMICALS: UNDERSTANDING THE ISSUES - 1988

This video, narrated by Hugh Downs, addresses the question "Can the nation's parallel needs for safe groundwater and high agricultural productivity be met?"

The president of The National Corn Grower's Association states "There is a great need for farmers to be more knowledgeable...because as the primary users of pesticides and water in this country, if we aren't a part of the solution, we will most certainly be viewed as part of the problem." Simple animation illustrates where groundwater comes from and how it moves. Most of the emphasis is placed on safe handling and storage of pesticides and contaminants reaching groundwater through direct routes of contamination (at specific points) as opposed to agricultural chemicals leaching through the soil to groundwater (as non-point pollution). According to the president of The American Soybean Association, much of the responsibility for protecting groundwater from pesticides rests with the individual farmer.

Monsanto, monetarily, supported the development of this video. The video was presented as a service to agriculture by The American Soybean Association and The National Corn Growers Association with funding provided by Monsanto. Contact one of the three above groups for additional copies.

10 Min. GROUNDWATER ON THE MOVE - 1989

This video of the groundwater flow model demonstration visually illustrates (with colored dye) important principles of groundwater movement and shows how agricultural chemicals and groundwater meet. The video may be used in lieu of demonstrating the flow model to illustrate forces and movement of groundwater, the water table, aquifers, pumping wells, and artesian wells. Direct and indirect paths of groundwater contaminates are demonstrated showing how surface pesticides and nitrates end up in drinking water. The flow model was designed and constructed by Jim Peterson, water quality specialist, Cooperative Extension Service, University of Wisconsin, Madison, Wisconsin, specifically for The Vocational Agriculture Curriculum.

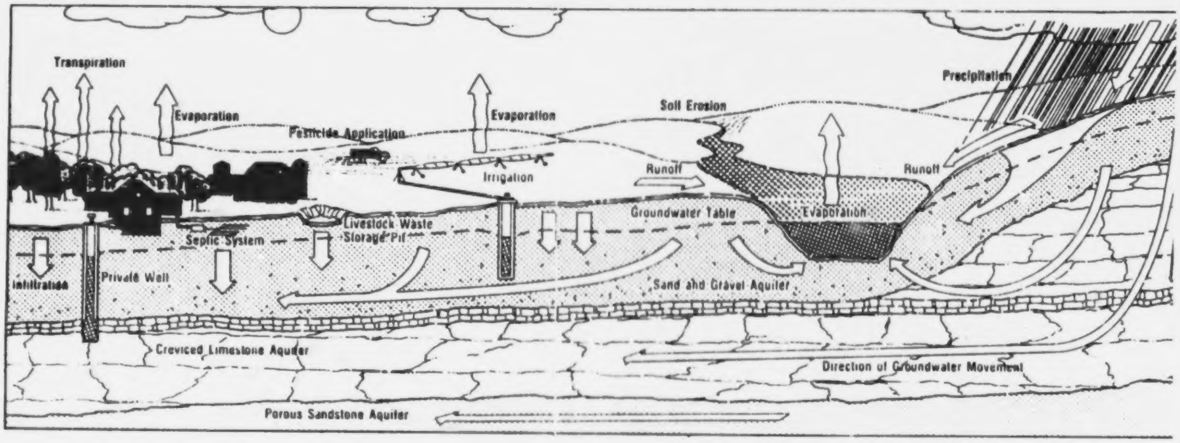
Eldon Weber, U.S. Soil Conservation Service (SCS), demonstrates the flow model illustrating the major agricultural groundwater contamination sources as contained in The Vocational Agricultural Curriculum.

The video script was developed by The Agricultural Education Department and The Department of Natural Resources (DNR). DNR filmed the video.

15 Min. OPERATION AND MAINTENANCE OF THE GROUNDWATER FLOW MODEL

The operation and maintenance segment of the groundwater flow model video was filmed by SCS using portions of a demonstration provided by Jim Peterson, University of Wisconsin. It is designed for educators who demonstrate The Flow Model.

RECOGNIZING GROUNDWATER CONCERNS


Transpiration
Evaporation
Pesticide Application
Evaporation
Soil Erosion
Precipitation
Irrigation
Runoff
Runoff
Livestock Waste Storage Pit
Groundwater Table
Evaporation
Septic System
Infiltration
Private Well
Sand and Gravel Aquifer
Creviced Limestone Aquifer
Direction of Groundwater Movement
Porous Sandstone Aquifer

EDUCATIONAL CONCEPTS

- Iowa's groundwater issues
- Agricultural issue priorities
- Issue analysis
- Water use impairment
- Point versus nonpoint pollution
- Energy conservation

Recognizing Groundwater Concerns

LESSON: Introduction to "Protecting Iowa's Groundwater Through Prevention"

GOAL:

Since you will be our future agriculturalists, it is important for you to understand the concerns we have with the quality of our groundwater. You must have enough knowledge and develop necessary skills to protect our groundwater through prevention using good farm management practices. You need to understand the energy and soil conservation benefits associated with water quality management practices.

OBJECTIVES:

Upon completion of this lesson, the participants will be able to:

1. Determine the groundwater quality concerns in Iowa.
2. Prioritize the agricultural issues in the protection of groundwater.
3. Determine how water quality affects different uses.
4. Distinguish between point and non-point pollution.
5. Analyze the relationship between energy conservation and groundwater quality.

MATERIALS:

Video player, videos - "Seeds of Survival" and "Groundwater and Agricultural Chemicals: Understanding the Issues," overhead projector,

VISUAL MASTERS:

VM-INTRO-1 Seven Issues Affecting Water Quality in Iowa
VM-INTRO-2 Water Impairment and Its Affects on Water Uses
VM-INTRO-3 Two Basic Classes of Pollution Sources

ACTIVITIES:

PRE-TEST Conservation Planning Exercise
ACT-INTRO-1 Videos - Balance the Issues Exercise
ACT-INTRO-2 & Key Identification of Pollution Types
ACT-INTRO-3 & Key Energy Conservation Exercise
ACT-INTRO-4 World's Water Supply
ACT-INTRO-5 & KEY Natures Water Cycle
ACT-INTRO-6 "Seeds of Survival" video exercise

INFORMATION:

INFO-INTRO-1 Seven Issues Affecting Water Quality in Iowa
INFO-INTRO-2 Priority Water Allocation Plan for Iowa

INTEREST APPROACH:

This introduction lesson "Protecting Iowa's Groundwater Through Prevention," will set the stage for a series of units to follow. This topic has high priority nationally, within the state, and in our community. In fact, these curriculum materials were made possible through the passage of the Iowa Groundwater Protection Act. You will find this topic exciting and you'll have maximum "hands-on" experiences. You'll want to think of how we can take this message to our community in the form of a community action program. One of life's fundamental needs is water. We

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Prepared by Don King, Department of Agricultural Education, Iowa State University, Ames, Iowa, June 1989.

need both a safe and dependable supply of water to maintain our health and standard of living. Review ACT-INTRO-1 prior to showing the videos: "Seeds of Survival" and "Groundwater and Agricultural Chemicals: Understanding the Issues."

PRETEST CONSERVATION PLANNING EXERCISE

Use this exercise as a pretest. Explain to participants that this same activity will be given as a posttest assignment to evaluate their comprehension of the eight groundwater units. Divide into groups of two or three to compete for the highest score. Use the same teams in the posttest. Review participants answers. Ask them to hand in their answers for comparison on the posttest. (Use the key found in Unit 8 only in the posttest). Explain that their answer sheets will be handed out at the conclusion of the groundwater units. (Participants should do much better on the posttest after they have completed the eight units).

TEACHING PROCEDURE:

1. What are the Seven Agricultural Groundwater Quality Concerns in Iowa? Use INFO-INTRO-1 and VM-INTRO-1 to identify 7 issues related to agricultural groundwater quality in Iowa. Ask students why they think each is important, and what potential affect it can have on them and their environment. Explain the importance of these issues and discuss the short and long term affects of each.

2. How does Groundwater Quality Affect Different Water Uses? Ask participants to write a brief definition of "water use impairment". Write them on the chalkboard. Use VM-INTRO-2 to compare the correct definition of 'water use impairment' with that of the participants and frame this discussion in an environmental context. Then break participants into small groups and have them identify the major classifications of water use in their area and in Iowa. Compare these answers with those listed on VM-INTRO-2. Ask groups to determine which of these water use classifications may overlap with another, and discuss to what extent this overlapping should be allowed, controlled, or prohibited. Using INFO-INTRO-2, explain that Iowa law has set a priority list of the order in which water use(s) may be cut off in case of a water shortage.

3. What are Point and Nonpoint Pollution Sources? Use VM-INTRO-3 to define point and nonpoint pollution. Ask participants for examples of each. Use ACT-INTRO-2 & Key to have participants identify the listed pollution sources as being either point (direct) or nonpoint (indirect) pollution types. Explain the importance of proper site selection for tanks and wells. Refer to pages 3, 4, and 13 of "Water Quality Field Guide" to understand principles of nonpoint pollution.

4. Throughout the groundwater education program you will see that management systems used in crop production to reduce water pollution will likewise reduce energy usage. In fact, many of the "unnecessary" tillage operations not only consume energy unnecessarily, cost more and take more time, but they also lead to soil erosion. Use ACT-INTRO-3 to illustrate.

CONCLUSIONS:

Review the objectives of the lesson and ask each of the participants to list and describe two of the major points discussed in this lesson.

Divide students into 7 groups. Assign each group one of the 7 issues and have them develop a method/program for educating the public about its' importance, thereby working to combat the issue. Have each group orally present their educational programs to the class.

OTHER ACTIVITIES:

1. Using ACT-INTRO-4 (both pages) show students the location of our world's water supply. Asks students the questions as outlined.

2. Using ACT-INTRO-5 and KEY-ACT-INTRO-5 have students identify where each component of the water cycle comes into play, thus having an effect on water quality.

3. Briefly discuss the Hydrologic Cycle (Water Cycle). Demonstrate this cycle by boiling water on a hot plate and holding a pan of ice cubes over the steam from the boiling water. Steam will condense when it hits the cold pan, and fall back into the water and change to steam again, completing the cycle.

4. An alternative activity would be to demonstrate the process of transpiration. One can easily illustrate this process by placing a clear plastic bag over two broad-leafed potted plants, of which each is approximately the same size and type as the other. Place one plant in a dark cool place, and the other in a warm, well lit spot. After a period of time the plant in the warm environment will show a much greater degree of moisture collected on the inside of the bag; a result of greater transpiration rate. Discuss how this moisture (water) transpires through the plant and evaporates into the atmosphere, and re-releases as precipitation, eventually seeping into the soil (infiltration) to form groundwater.

5. Work with participants to develop FFA-Supervised Agricultural Experience (SAE) projects designed around water quality. Identify on-farm sources of pollution and pollution entry.

6. Plan an FFA Chapter Community Service Project where the chapter will collect and test resident water sources for nitrate and bacteria.

7. Invite local water quality specialists to speak to your class.

8. Compare the number of newspaper, magazine articles on resources with that of other pertinent and timely societal concerns, to see the amount of press coverage and attention devoted to each issue. Discuss why these issues are topical.

9. Use ACT-INTRO-6, from Film Fair Communications to further discuss video "Seeds of Survival."

BALANCING THE ISSUES

Objective: After viewing each video, participants will be able to recognize bias from various interest groups on groundwater concerns. After viewing the videos, participants will be able to appreciate the need for the public to develop skills in reducing groundwater contamination.

INTEREST APPROACH:

Two videos have been selected for you to show. Both illustrate why farmers and the general public are concerned about groundwater contamination. "Groundwater and Agricultural Chemicals: Understanding the Issues," was developed by Monsanto and taped in 1988 and "Seeds of Survival", taped in 1983, was developed by KMTV, Omaha, and Public Television. The aim is for participants to become familiar with surrounding groundwater contamination and realize we are being bombarded by special interest groups working for their cause. We need to be as objective as possible to sort out the facts. Show "Groundwater and Agricultural Chemicals: Understanding the Issues" first and have participants answer the associated questions.

Then view "Seeds of Survival", have participants answer the associated questions and compare the messages of both videos.

COMPARE THE ISSUES

Both of the videos you will view have important messages, aimed at individual causes. They are trying to sell. It is important for you to understand that you are exposed to information designed to sell special interest causes on a daily basis on a great many topics. It is necessary for you to separate facts from emotions; and information slanted to selling ideas and products from facts. It is important to remember there is more than one side to an issue and it is up to farmers to look at many sources of information, weigh the issues and make intelligent decisions. These decisions should not only be good for them, but for future generations. During this exercise you will be asked to compare short-term economic issues with environmental issues by using information provided by special interest groups.

"Groundwater and Agricultural Chemicals: Understanding the Issues"

(Developed by the National Corn Grower's Association and the American Soybean Association through a grant from Monsanto, a mid-western based company that develops and sells agricultural pesticides)

1. The following quotes were taken from the video you just saw. Discuss whether you think the quotes were objective or whether they were slanted toward selling an idea or product.

a. "the simple fact is that productivity and economic viability mean nearly the same thing"

- Increased yields do not necessarily mean increased profits. Lowering inputs i.e., by scouting for pest damage before applying chemicals may very well reduce the need to spend as much on chemicals.

b. " . . . . chemicals can be good for the environment."

- This statement was not explained in the video. Many chemicals are natural in the environment. However, chemicals in the form of fertilizers and pesticides are causing serious damage to our water. In fact, these materials were written because of the concern the public has about groundwater quality.

c. "the most common type of groundwater contamination is by direct routes"

- Many scientists would say this may not be true. Currently, research is being done to determine the amount of contamination by water movement through the soil. For example, the Iowa Department of Natural Resources has research in the Big Spring Basin in northeastern Iowa and other areas that indicate the main way agricultural chemicals reach groundwater is by leaching through the soil, rather than by "direct routes". It appears from this video that the producers want the viewers to believe that we need only to correctly handle and store agricultural chemicals to ensure we have clean groundwater.

d. "you can measure chemicals in water at levels far below any significant level of risk."

- Most, if not all, scientists would say this statement is false. It is important that students understand that when several pesticides contaminate water, they may produce health effects in combination that are greater than the sum of their individual toxic effects. As of 1986, the Environmental Protection Agency (EPA) had only set drinking water standards for six pesticides. Most of the most commonly used pesticides do not have drinking water standards so no one knows the "levels of risk".

e. "pesticides represent only a small portion of the overall groundwater residue picture"

- In the EPA study, 17 pesticides had been found in groundwater in 23 states.

2. Discuss why Monsanto would fund a video such as the one you just saw.

- Monsanto is very concerned about safety and the proper use of their product. They want to educate the public on the correct handling and storing of agricultural pesticides and improve their public image. The video will be used later to provide excellent information on handling and storing pesticides. Also, to influence the participant to believe that if he or she just handles the chemicals correctly, the problem of agricultural chemicals contaminating groundwater will be solved. (Improved handling will lessen the problem, but not solve the main problem.)

3. Who narrated this video? Why would using a well-known television voice to narrate a video or film help sell the film producer's message?

   - Hugh Downs, commentator for "Twenty-Twenty". Since "Twenty-Twenty" is a news show, we have been conditioned to trust the journalist associated with this program.

4. Discuss what you think is meant by this quote "land cannot be owned, it is merely borrowed from future generations".

"Seeds of Survival" is a video developed in 1983 by KMTV Omaha, and by Public Television

1. Discuss the following:

   a. Think back to the scene where the female farm renter was being tested for cancer at the hospital. What feelings did this scene invoke in you? How do you feel about this?

      - Open

   b. "The only way soils can be built is organically". Discuss this quote.

      - Soil is developed very slowly as organic matter is decomposed and mixed with other elements. Adding synthetic fertilizer to the soil does not add organic matter. Since soil development is very slow, it is essential that we protect what we have to prevent excessive erosion.

   c. Is there evidence that farm chemicals are linked to a higher incidence of cancer?

      - Some pesticides have been linked to cancer.

2. Discuss how the creators of this video made you feel about the agriculture chemical problems on the farm? Why would an Omaha T.V. station and Public Television develop such a video?

   - Open

3. Who narrated this video? Does this contribute to the bias of the video? Do you think this video is slanted too much to the environmental side?

   - Dennis Weaver, well-known for his role in "Gunsmoke". Again a well-known person was used to sell the cause for a needed change to improve our environment.

4. In the video, John Block, former United States Secretary of Agriculture, said "I don't feel they (chemicals) are dangerous. I feel we are using the proper amounts." Discuss whether you agree with him, and why the producers of the video used this quote.

   - Some reasons that former Secretary Block used may be to show that farmers can not necessarily depend on elected or appointed officials to accurately inform them as to important issues. Also at the time this was filmed in 1983, there was less concern in the quality of our groundwater.

5. What changes are some farmers making in an effort to reduce water pollution and other environmental problems? The details for this will be revealed in later units of these materials.

   - Answers could include: more crop rotations to break up the insect cycle, use of manures and crop rotations to reduce the amount of commercial fertilizer needed, reducing the amount of chemicals used and organic farming.

The message of "Seeds of Survival" is as true today as it was in 1983, with one exception, a greater awareness of the problem now exists. Legislation has been initiated to provide for low input sustainable agriculture incentives. USDA has made a major shift in emphasis since the film was produced. Water quality will be the center of attention in the 1990 Farm Bill. The 1988-1997 National Program for Soil and Water Conservation (RCA), directs USDA to improve and protect the quality of surface and groundwater and emphasize cost-effective alternative farming systems.

6. Discuss why the Office of Organic Farming was eliminated from USDA during the taping of this video. Do you think the National Corn Growers Association and the American Soybean Association will do what they can to help farmers make the switch to sustainable agriculture?

   - Open

Conservation Planning Exercise

Situation

You are the owner of 320 acres (see scaled map) and a house in town. You have met with your county Soil Conservationist and together you have prepared a conservation plan for your farm. This plan accomplishes two purposes: (1) to control erosion and (2) to remain eligible for the 1985 Food Security Act.

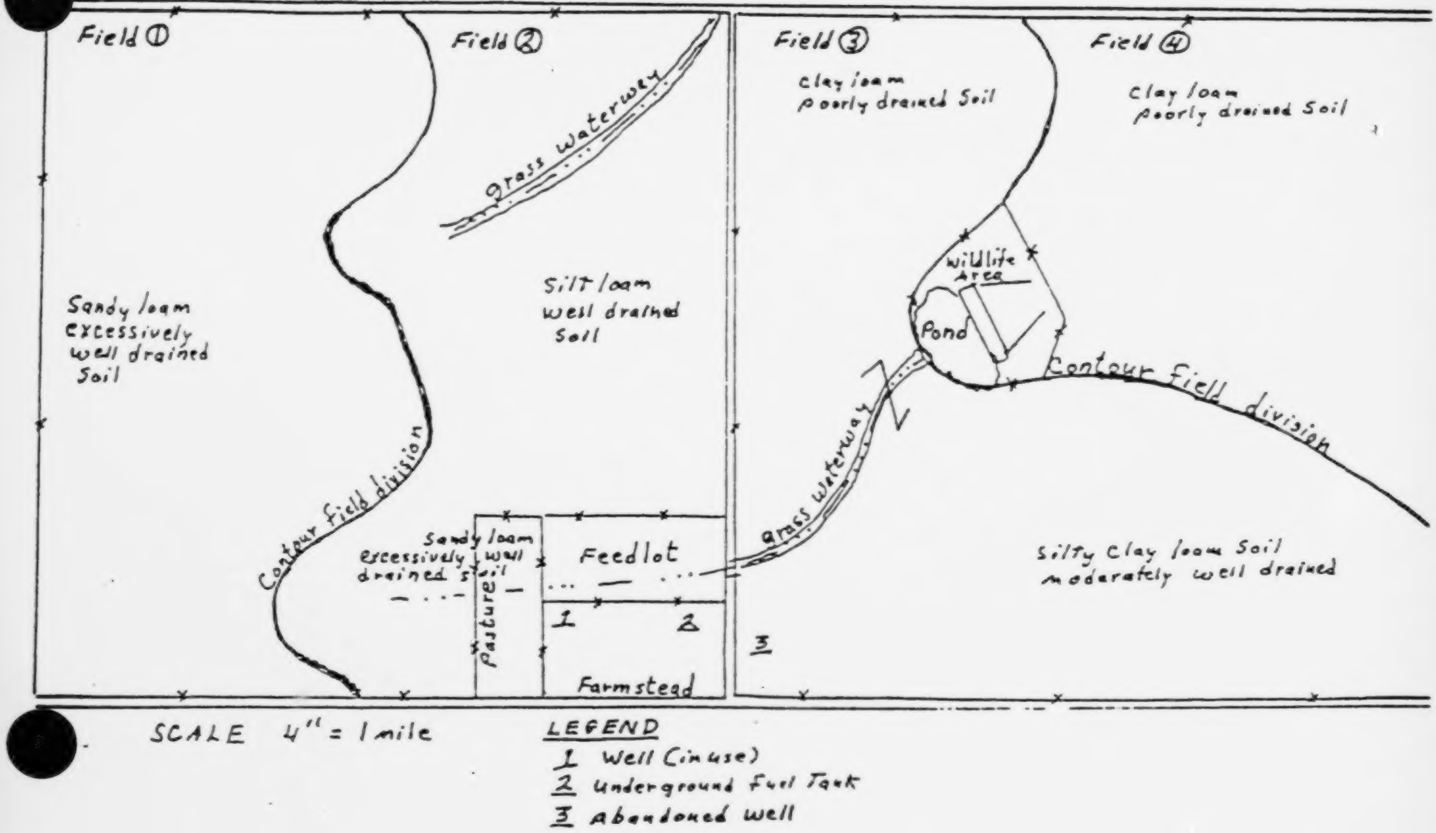
In addition, you feed 100 head of cattle each year and spread their manure on a small pasture located next to the feedlot. This pasture is on a sandy soil which is excessively well drained. Gasoline is stored in an underground tank (over 20 years old) as a safety precaution. The well you use for your on-farm household is located close to the feedlot and pasture. There is also an abandoned well on your farm, as well as a pond and wildlife area downstream from the feedlot.

You grow continuous corn and you apply an ample amount of pesticides (broadcast) because you don't want to take the risk of insect or weed problems. The use of a cultivator to control weeds is seldom used.

The county soil survey report shows that the soils on your farm have an average annual yield potential of 100 bu. of corn/acre under good management. You apply nitrogen each year at a rate estimated to produce 150 bushels of corn/acre Fertilizer is purchased and applied (broadcast) in the fall to take advantage of lower costs.

You are following your conservation plan using practices such as contouring and conservation tillage to control erosion on gently sloping land. You have become concerned about how your farming operations may be adding to water pollution, and you want to revise your conservation plan using energy conservation and cost effective farming systems to reduce water pollution.

Furthermore, you suspect you have been using an excessive amount of lawn and garden chemicals on your property in town and feel you have been somewhat careless in the handling of these materials. You want to improve your management of lawn and garden pests to reduce the water pollution potential.


Field ①
Field ②
Field ③
Field ④
Sandy loam excessively well drained Soil
grass waterway
Silt loam well drained Soil
Contour field division
Sandy loam excessively well drained soil
Pasture
Feedlot
1
2
Farmstead
clay loam poorly drained Soil
Clay loam poorly drained Soil
Wildlife Area
Pond
Contour field division
grass waterway
Silty clay loam Soil moderately well drained
3
SCALE 4" = 1 mile
LEGEND
1 Well (in use)
2 Underground Fuel Tank
3 Abandoned well

To broaden your conservation plan to a sustainable agriculture, and energy conservation, farming system complete the following:

Assignment #1 : Analyze your farming operations to determine potential water pollution problems. Make a list of the problems which you think need to be corrected.

Assignment #2 : What management practices will you use to eliminate the potential water quality problems which you have identified?

Assignment #3 : Develop a cropping schedule on how you would convert from a continous corn cropping system to a sustainable agriculture system, using reduced pesticides and commercial nitrogen. What crops would you grow in each field in 1990, 1991, 1992, 1993, maintaining approximately the same acreage of each crop each year?

	1989	1990	1991	1992	1993
Field 1	Corn				
Field 2	Corn				
Field 3	Corn				
Field 4	Corn				

Assignment #4 : How would the practices outlined above conserve energy (petroleum products)?

Assignment #5 : How do you plan to reduce chemical use and improve safety on your lawn and garden in town?

Seven Issues Affecting Water Quality In Iowa -- In Priority Order

1. Agricultural Use of Nitrogen Fertilizers:
    - About 10 times as much nitrogen fertilizer is used on Iowa farms today than 30 years ago and a parallel increase in nitrate levels has been found in Iowa's groundwater
    - Resulting in potential health risks: blue-baby syndrome, hypertension, & possibly cancer
    - About 26% of Iowa's population are served by high nitrate surface water or groundwater
2. Agricultural Use of Pesticides:
    - Concentrations (generally less than 5 ppb) are now being found in shallow groundwaters in Iowa - low concentrations of some pesticides may cause environmental and health problems.
    - 9 herbicides and 3 insecticides have been detected by monitoring Iowa's public water supplies
    - Major sources of these pollutants may be from use on farm fields (For example, evidence of atrazine has been found in field tiles)
    - About 27% of Iowans are periodically consuming pesticides in their water
    - Resulting health effects: links to some cancers, including leukemia, and melanoma
3. Underground Tanks and Pipelines:
    - Underground -- risk reduced for fire, but increased for groundwater contamination, because closer to the water table and ability to detect leaks is greatly reduced: small leaks have great impact over time.
    - EPA national study showed 25% of the existing underground tanks had leaks.
    - In Iowa, 85% of the reported tank leaks resulted in contamination of groundwater.

4. Hazardous Substances Handling/Storage:
   - In Iowa potential sources of spills, leaks, and runoff from above ground storage tanks include: 146 regulated hazardous waste facilities; over 1,400 auto repair and service garages; about 1,300 agri-chemical dealerships; and numerous barge and railroad terminals; petroleum tank farms; and on-farm handling of hazardous substances.
5. Direct Paths of Contamination:
   - Any hole in the ground that reaches an aquifer can carry pollutants.
   - Three direct paths of contamination in Iowa are of special concern: agricultural drainage wells, abandoned wells, and sinkholes.
6. Land Applied Solid/Liquid Wastes:
   - The application of animal wastes, industrial wastewater treatment sludges, and municipal sewage sludge on the land surface is an alternative to burning or discharging wastes into streams and rivers.
   - Application guidelines need to be followed to prevent groundwater contamination by: bacteria, nitrates, or other chemicals contained in sludges.
7. Urban Use of Fertilizers/Pesticides:
   - Urban use does have potential for contaminating groundwater, but only 2% of these chemicals are used in urban areas.
   - Greatest risk in urban areas may be due to direct contact by children and pets

Source: Iowa Groundwater Education Strategy
August, 1988
Iowa Department of Natural Resources

Seven Issues Affecting Water Quality In Iowa

- Agricultural Use of Nitrogen Fertilizers
- Agricultural Use of Pesticides
- Underground Tanks and Pipelines
- Hazardous Substances Handling/Storage
- Direct Paths of Contamination
- Land Applied Solid/Liquid Wastes
- Urban Use of Fertilizers/Pesticides

Water Impairment and its Effects on Water Uses

1. Water becomes polluted after a certain level of contamination has been reached. At that time the water is said to be impaired. It's use is restricted to certain activities or functions.

2. Impaired use means that the quality of the water is unfit for a specific use. For example, water suitable for non-contact recreation (boating) may be impaired for use by humans. Water used for irrigation may be impaired for use by livestock.

3. Water Classifications:
   - Agricultural
   - Wildlife
   - Aquatic Life
   - Transportation
   - Municipal Water Supply
   - Industrial Water Supply
   - Energy Production
   - Recreational: Primary Contact
     Secondary Contact

Priority Water Allocation Plan For Iowa

The Iowa Department of Natural Resources may suspend or restrict usage of water by category of use on a local or statewide basis in the following order:

a. Water conveyed across state boundaries.

b. Water used primarily for recreational or aesthetic purposes.

c. Uses of water for the irrigation of hay, corn, soybeans, oats, grain sorghum or wheat.

d. Uses of water for the irrigation of crops other than hay, corn, soybeans, oats, grain sorghum or wheat.

e. Uses of water for manufacturing or other industrial processes.

f. Uses of water for generation of electrical power for public consumption.

g. Livestock production.

h. Human consumption and sanitation supplied by rural water districts, municipal water systems, or other public water supplies.

i. Human consumption and sanitation supplied by a private water supply.

** Notice that water for irrigation purposes is among the first to be cut.

TWO BASIC CLASSIFICATIONS OF POLLUTION SOURCES

* **Non-Point Source Pollution**

Pollution of the water from numerous, widespread locations that are hard to identify.

Ex: Agri-chemicals through leaching or runoff

* **Point Source Pollution**

Pollution of water from one place in a concentrated manner that is easy to identify.

Ex. Leaking underground storage tank or an overturned chemical truck/trailer.

Identification of Pollution Types

Various sources of pollution are listed below. Identify each as to whether it is either point or non-point pollution. (Some could be both)

- A leaking undergound petroleum tank.
- Sediment eroding from a field.
- A private septic tank.
- Nutrients being leached into the groundwater.
- Animal wastes tilled into a field.
- Animal wastes in a sludge/sump pond.
- Improper disposal and storage of solid and hazardous wastes.
- Pesticides sprayed on a field.
- Crop chemicals washing from field into an old well casing.

Identification of Pollution Types

Various sources of pollution are listed below. Identify each as to whether it is either point or non-point pollution.

P	•A leaking undergound petroleum tank.
NP	•Sediment eroding from a field.
P	•A private septic tank.
NP	•Nutrients being leached into the groundwater.
NP	•Animal wastes tilled into a field.
P	•Animal wastes in a sludge/sump pond.
P	•Improper disposal and storage of solid and hazardous wastes.
NP	•Pesticides sprayed on a field.
Both	•Crop chemicals washing from field into an old well casing.

ENERGY CONSERVATION EXERCISE

Exercise: (group or individual)

For the following management practice, describe the effects on energy usage and water quality.

Description of a Management Practice (banding)

Situation: You change **from** broadcasting (applying over entire field) nitrogen and pesticides, **to** banding (applying in a narrow band over each row). Place the following questions on the blackboard.

1. How would the band application of pesticides and nitrogen save energy?

2. How would it reduce water contamination?

KEY-ACT-INTRO-3

1. *Answer:* Using less chemical results in less energy used in manufacturing and less energy fuel used in transporting the chemical from the source to the farm.
2. *Answer:* When less chemicals are applied to a field, a lesser amount will be available for leaching into the groundwater.

WATER OF THE WORLD DEMONSTRATION

Looking at the total world's water supply contained in the Water Connection Cycle (Hydrologic Cycle), if a 55 gallon drum filled to capacity with water, was representative of all the water in the world, how much would represent the water in our oceans?

--- Answer: 53 gals., 1 qt., 1 pt., 3 oz.

Using 2 one gallon milk bottles (each filled with water), a quart jar, a pint jar, a glass measuring cup, and a bucket to catch the excess water, conduct the following demonstration.

Ask students: How much of the world's water is contained in groundwater and soil moisture ?

Demonstrate: From one of the gallon bottles, completely fill the quart jar, and place 11.5 ounces in the measuring cup. Based on the 55 gallon barrel of water, this amount represents the amount of the worlds water contained in groundwater and soil moisture. Of this 1 quart and 11.5 ounces, only 1/4 oz. represents the soil moisture (that moisture within the soil profile above the water table).

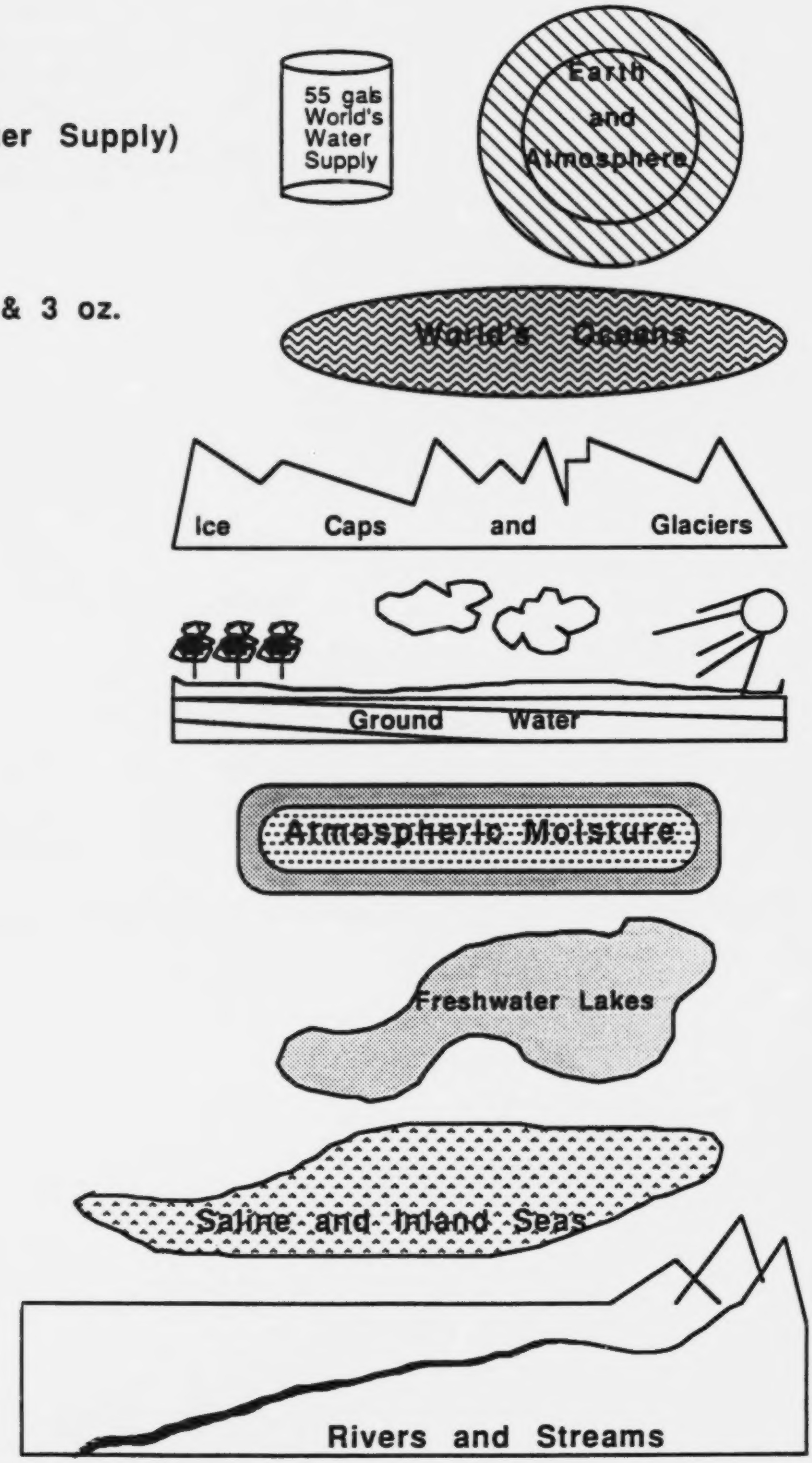
Other portions of the Water Connection Cycle may be demonstrated in this manner.

Other possibilities for this exercise might include having students fill those containers (of various sizes) which they feel represent corresponding amounts of world water. This could be done prior to the actual demonstation.

ACT-INTRO-4

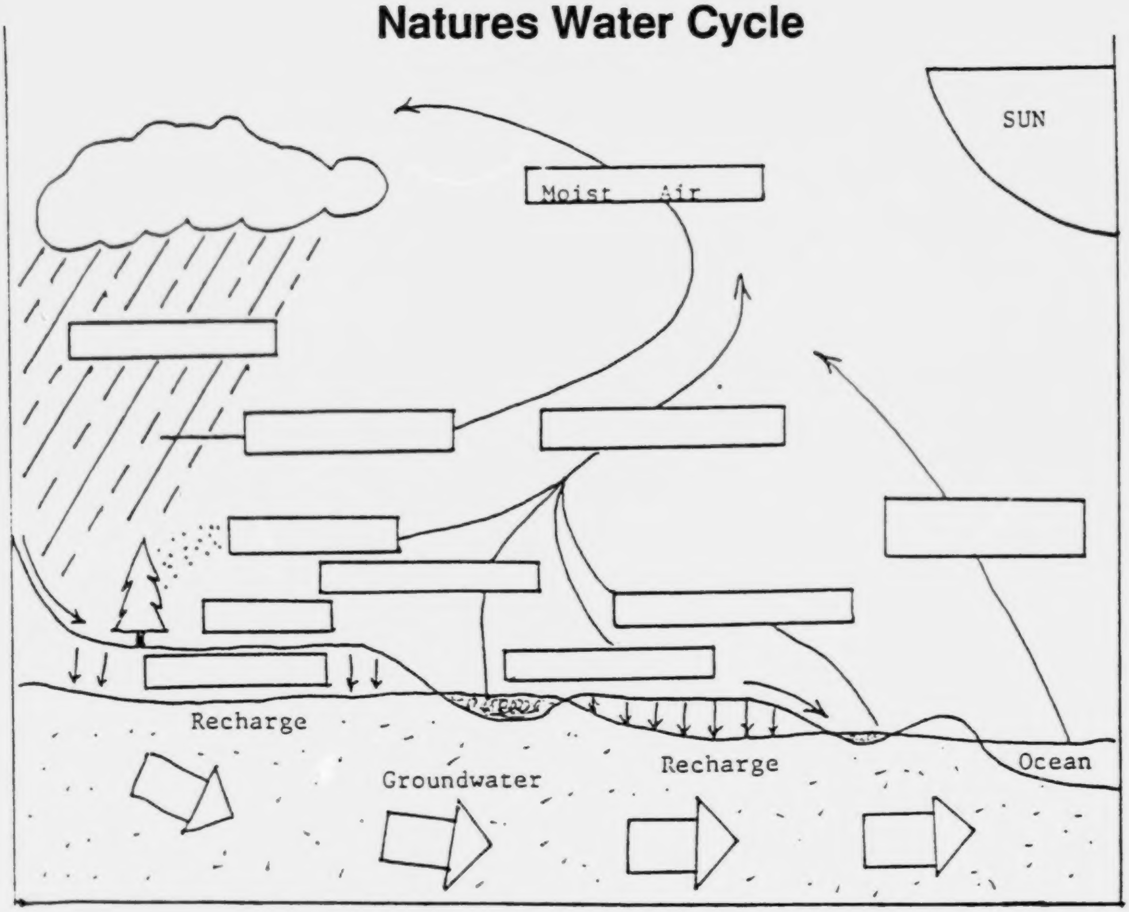
# World's Water Supply

55 gal. (World's Water Supply)	100%
53 gal., 1 qt., 1 pt., & 3 oz.	97%
1 gal., 12 oz.	2%
1 qt., 11.4 oz.	.6 of 1%
1 pt., 4.5 oz.	.2 of 1%
.5 oz.	.007 of 1%
.34 oz.	.004 of 1%
.01 oz.	.00014 of 1%


55 gals World's Water Supply
Earth and Atmosphere
World's Oceans
Ice Caps and Glaciers
Ground Water
Atmospheric Moisture
Freshwater Lakes
Saline and Inland Seas
Rivers and Streams

SOURCE: ADAPTED FROM THE HYDROLOGIC CYCLE, U.S. GEOLOGICAL SURVEY, 1984

Natures Water Cycle


SUN
Moist Air
Recharge
Groundwater
Recharge
Ocean

Water Cycle = ______________________ **Cycle**

Condensation - ______________________________

Evaporation - ______________________________

Groundwater - ______________________________

Hydrologic Cycle - ______________________________

____

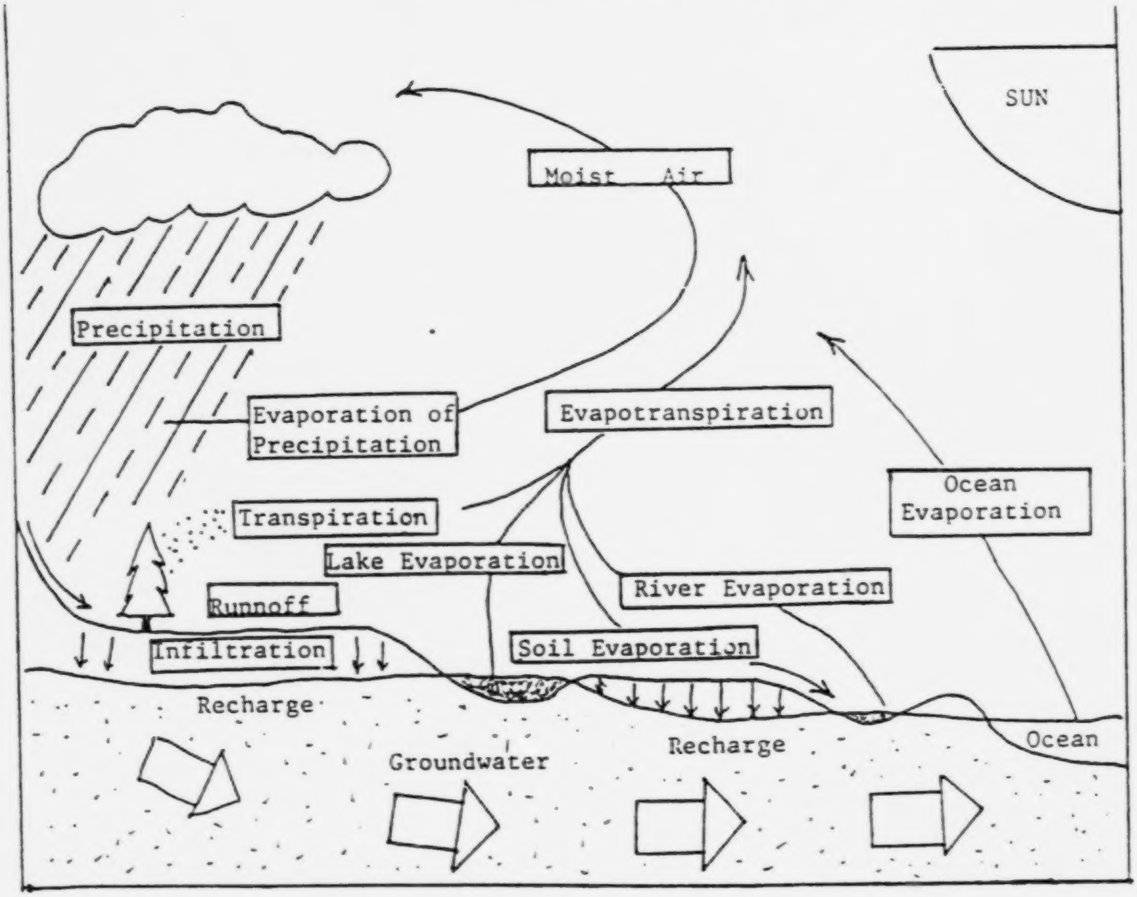
Infiltration - ______________________________

Precipitation - ______________________________

____

Runoff- ______________________________

Natures Water Cycle


SUN
Moist Air
Precipitation
Evaporation of Precipitation
Evapotranspiration
Ocean Evaporation
Transpiration
Lake Evaporation
River Evaporation
Runnoff
Infiltration
Soil Evaporation
Recharge
Groundwater
Recharge
Ocean

Condensation - The changing of water vapor to liquid.

Evaporation - The changing of water into water vapor.

Groundwater - Water found below the surface of the earth.

Hydrologic Cycle - Process involving the circulation and distribution of water on the earth.

Infiltration - The process by which water seeps into the soil.

Precipitation - Forms of condensec water vapor that are heavy enought to fall to the earth's surface, such as rain, snow, sleet, and hail.

Runoff - Water that doesn't enter the soil, but flows in the direction of least resistance.

SEEDS OF SURVIVAL

A Film by Pamela Roberts

SYNOPSIS:

Alan and Delores Hilt are Nebraska Farmers. Over the years, they and many of their farming neighbors have become dependent on synthetic fertilizers and pesticides to bolster their crop yield and income. Once considered a boon to American agriculture, the use of chemicals has proven to be a mixed blessing: it has reduced soil fertility, increased production costs and raised concerns that the chemicals may be polluting the water and soil. Consequently, many farmers believe they must return to organic methods of farming and rebuild their soil by reducing their dependence on chemicals. It takes several years to make that transition and during that time, crop yields and income are greatly reduced.Unfortunately for the Hilts and many of their neighbors, the financial risk may be too great to bear. Concerned for the future, the Hilts continue to look forward to a time when they can reduce their dependence on agricultural chemicals and reap the benefits of lower production costs and rejuvenated soil. Ironically, their yearly struggle for economic survival may prevent them from doing that.

AFTER VIEWING:

1. For what purposes are agricultural chemicals used?
2. What is meant by the term "Organic Farming"?
3. How has the use of chemical fertilizers and pesticides benefitted American agriculture?
4. What is "crop rotation"? How does it contribute to farm's productivity?
5. How did farmers change their planting procedures after the introduction of agricultural chemicals?
6. Why did farmers become dependent on the use of agricultural chemicals?
7. What environmental and health concerns have arisen regarding the use of agricultural chemicals?
8. What are the benifits of Organic Farming?
9. What economic factors determine whether a farm will show a profit or loss on the crops it sends to market?
10. Describe the economic problems facing the average farmer today?
11. How does a farmer's indebtedness affect his ability to make a profit on his crops?
12. What other problems can affect the productivity and economics of farming?
13. How do these problems, economic and otherwise, make it difficult for farmers to reduce their dependence on chemicals and switch to organic methods of farming?
14. How have farmers attempted tp promote the use of organic farming methods?
15. Contrast the position taken by the Federal Government regarding the use of chemicals in agriculture and that of the U.S. Department of Agriculture regarding the promotion of organic farming methods.

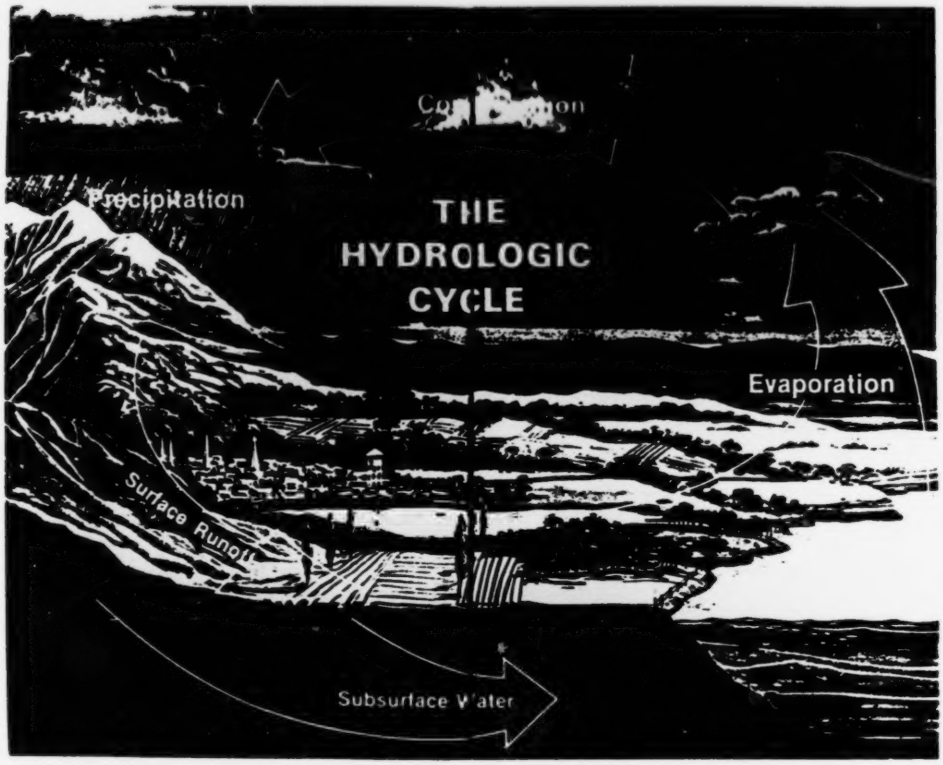
Grade Levels:
Junior & Senior High / College / Adult

Subject Areas:
Social Studies/Agriculture/Agri-Business/Contemporary American Problems/Science/Crop Rotation/Environment/Health Hazards/Risk Reduction

27¼ Minutes - Color
Released 1983

FilmFair Communications
10900 Ventura Blvd.
Studio City, Calif.
91604
(818) 985-0244

DESCRIBING THE WATER CONNECTION


Condensation
Precipitation
THE HYDROLOGIC CYCLE
Evaporation
Surface Runoff
Subsurface Water

Unit 2: DESCRIBING THE WATER CONNECTION

EDUCATIONAL CONCEPTS

- Watershed affects
- Susceptibility of groundwater contamination
- Geology
- Water cycle

Describing the Water Connection

LESSON: Understanding the Connection Where Agrichemicals and Groundwater Meet

GOAL:

To understand 'The Connection' where agrichemicals and groundwater meet, one needs to follow the raindrop through the earth's plumbing system. Surface water and groundwater are interconnected making it important to understand water movement from the earth's surface to the source of our drinking water.

OBJECTIVES:

Upon completion of this lesson participants will be able to:

1. Explain how groundwater moves.
2. Analyze the groundwater contamination and purification process.
3. Determine the role of forest and prairie ecosystems in the surface and groundwater network.
4. Analyze the susceptibility of an area to groundwater contamination.
5. Compare how different watershed components effect groundwater quality.

MATERIALS & REFERENCES:

Two potted plants, plastic bags, rubberbands, two gallon milk containers, soil, food coloring, water, a contour map of your county (optional)), Groundwater Flow Model or the Video, Groundwater Flow Model Manual, the Journal of Freshwater, the groundwater flow diagram/illustration (provided with curriculum materials), Self Help - Protecting our Groundwater

Specific geology information for your part of the state is available from:
Geological Survey Bureau, Iowa Department of Natural Resources,
123 N. Capital Street, Iowa City,
IA 52242, (319) 335-1575

VISUAL MASTERS:

VM-HYDRO-1	Growing Reliance on an Unseen Resource
VM-HYDRO-2	Water Quantity Relationships
VM-HYDRO-3	Illustration of Soil-Plant-Water Relationships
VM-HYDRO-4	Subsurface Cross-Section of a River Valley
VM-HYDRO-5	Geological Conditions & Groundwater Contamination

ACTIVITIES:

ACT-HYDRO-1 & Key	Watershed Considerations
ACT-HYDRO-2 & Key	Watershed Components
ACT-HYDRO-3 & Key	Principles of a Contour Map and Watershed Area
ACT-HYDRO-4	Groundwater Questions
ACT-HYDRO-5	Basic Concepts and Practices
ACT-HYDRO-6 & Key	Site Selection Exercise
ACT-HYDRO-7	Principles For Presentations
ACT-HYDRO-8	Soil Aeration and Porosity

INFORMATION:

Prepared by Don King, Department of Agricultural Education, Iowa State University, Ames, Iowa, June 1989.

INFO-HYDRO-1	Drinking Water Quality Problems in Iowa
INFO-HYDRO-2	Principles of Groundwater Flow
INFO-HYDRO-3	Roles of Forests
INFO-HYDRO-4	Aquifers and Aquitards

INTEREST APPROACH:

A day or two before this lesson is to be taught, distribute pages 1-3 of Self-Help Checklist for Farmsteads and Fields to participants and have them complete it as a homework assignment. In conjunction with a teacher led discussion, have students develop a "news release" for their local newspaper as a way to report their findings. Using VM-HYDRO-1, and pages 7 & 8 of the Journal of Freshwater, ask participants the following questions:

1. What percent of the U.S. population depends on groundwater for their drinking water? (Answer: Approximately 50%).

2. What percent of the U.S. rural population depend on groundwater for their drinking water? (Answer: Approximately 97%).

3. What percent of Iowa's population depends on groundwater for drinking? (Answer: Approximately 80%).

Discuss "Well Contamination" problems in Iowa by reviewing INFO-HYDRO-1. In this lesson we want to understand surface water and groundwater relationships so we can protect our water resource through the prevention of pollution.

TEACHING PROCEDURE:

1. Groundwater and surface water are interrelated. Both these types of water are actually parts of the same natural "plumbing" system called the Hydrologic Cycle. In this lesson, we are first going to discover the relationship between earth's natural plumbing system and the environment. Use VM-HYDRO-2 to illustrate quantity relationships of precipitation, evapotranspiration, and runoff.

Ask participants, "What is the relationship between Iowa's annual precipitation and the hydrologic cycle? In discussing this question, keep in mind that the following statistics are an average for Iowa. In reality, these figures would vary from the area of least annual precipitation in the NW part of the state to the area of greatest annual precipitation in the SE part of the state.

* Iowa's annual precipitation is approximately 25-36 inches/yr. (92% rain, 8% snow).
* Average runoff is approximately 3-4 inches/yr.
* Infiltration rate is approximately 26-27 inches/yr.
* Evapotranspiration rate is approximately 24-25 inches/yr.

Several characteristics of the hydrologic cycle have been discussed. Now look at the parts of this cycle in relation to water quality issues. Use ACT & Key-HYDRO-1 to discuss watershed factors affecting water quality. Use ACT & Key-HYDRO-2 to discuss how climatic, geographical, and human cultural activities can independently (or in partnership) affect the quality of our water in Iowa. Use ACT & Key-HYDRO-3 to discuss the earth's surface and subsurface features, and to give participants experience in outlining a watershed on a contour map and thinking through the potential surface pollution transport routes. The watershed concept is important in understanding how the earth's surface controls surface water and surface pollutants.

How are the earth's natural plumbing system and groundwater related? Use the enclosed pamphlet called "Protecting our Groundwater" to illustrate this concept.

Use the Groundwater Flow Model (or show the Groundwater Flow Model Video) to demonstrate principles found in ACT-HYDRO-4. Use the Groundwater Flow Model Manual and INFO-HYDRO-2 as references.

2. The Contamination and Purification Process. Ask participants, "What are the natural filters in the earth's plumbing system?" (Answer: Soil, plants, organic matter and wetland areas).

   Demonstrate how the soil helps to purify water (under the right conditions), by using the following procedure. It should be noted that there are many contaminants that do not attach to the soil. For example, some chemicals and fuels leach through the soil to the groundwater.

   A. Cut the bottom out of plastic jugs and fill each with a different soil type. Remove the bottle caps and invert the jugs and pour in dirty (dyed) water. Collect water as it drips through the spout. Emphasize that even though the water may appear clear, it may still be contaminated for a specified use. Soils may filter certain contaminants from the water, while other contaminants are left unfiltered. Thus, these contaminants may enter the groundwater.

   B. Using ACT-HYDRO-5 and VM-HYDRO-3, discuss and illustrate the soil-plant-water relationship.

   C. Distribute INFO-HYDRO-3 to participants for review. Guide participants through this material while discussing how forest vegetation differs (in type and importance) from other varieties of vegetation.

3. Susceptibility to contamination. Use VM-HYDRO-4 and VM-HYDRO-5 to discuss the variation of subsurface textures, structures, and how they relate to aquifer recharge. Use INFO-HYDRO-4 and VM-HYDRO-5 to illustrate the general variations of Iowa's aquifers.

4. Site Selection. Use ACT-HYDRO-6 to illustrate the many factors which influence the behavior and movement of contaminants in the soil.

OTHER ACTIVITIES:

1. Using ACT-HYDRO-7, divide participants into groups and ask each group to review the handout and to prepare a group presentation. Each group should have access to the chalkboard or to other visual aid materials, as they need. Assign each group a principle(s) from this handout, as the subject of their presentations.

2. Use ACT-HYDRO-8 to illustrate soil porosity and aeration principles. A room full of ping-pong balls and a room full of bowling balls result in the same pore space. This can be demonstrated by using two small jars, one filled with bee-bees and the other with marbles, and measuring the amount of water that can be held in each.

3. Invite local/regional water district representatives to speak to the class on the quality of the local drinking water supply.

SUMMARY:

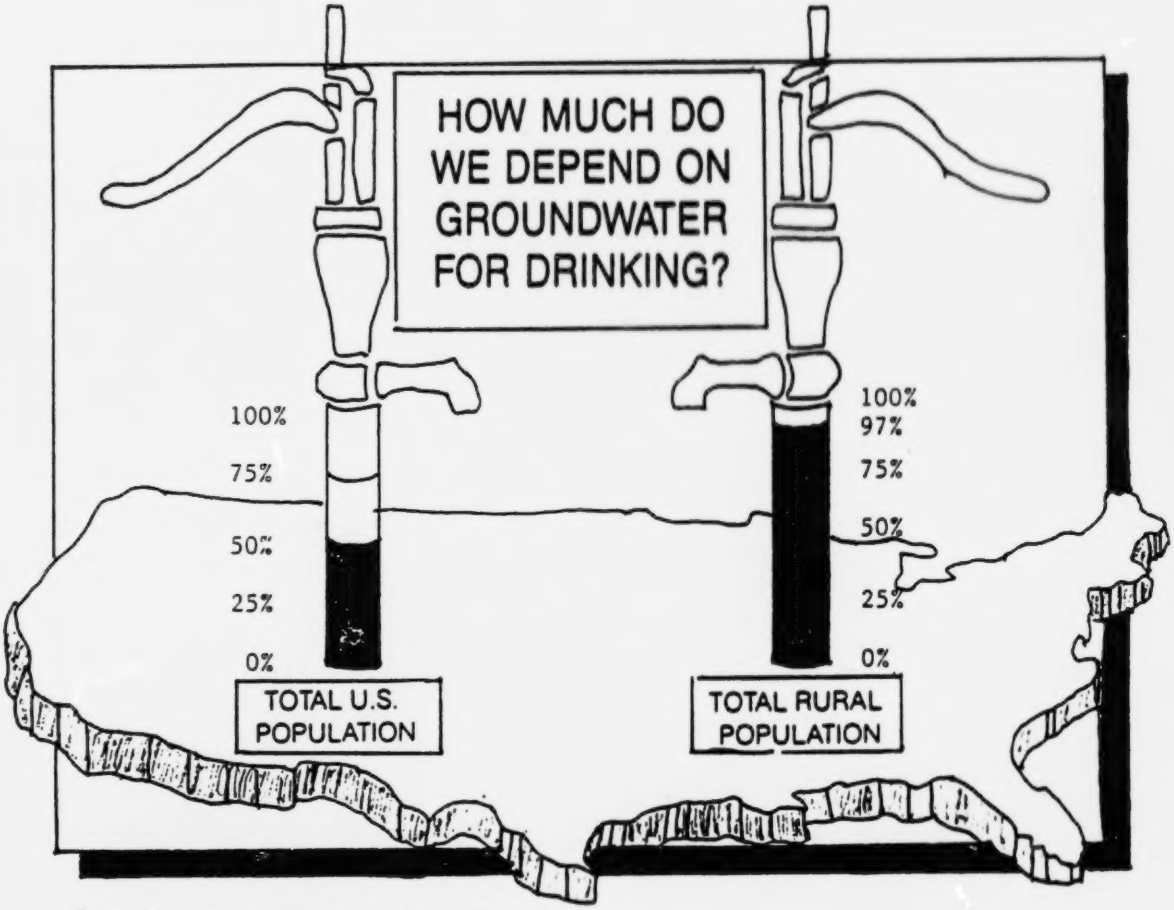
1. Review lesson objectives.

2. Have participants complete a short essay to cover those major aspects of the lesson as it affects groundwater quality.

Growing Reliance on an Unseen Resource

by Linda Bruemmer

We drink it, we irrigate with it, we use it for industry and for domestic supplies across the country: We depend on groundwater. These many uses of groundwater affect its quantity and quality--and therefore directly affect our lives and lifestyles as well.



Source: Journal of Freshwater

Drinking Water Quality Problems in Iowa

I. Problems That May Threaten Health

Contaminant	A. Coliform Bacteria*	B. Nitrate	C. Pesticide	D. Lead	E. Gasoline/Organic Solvents
Possible health effect (varies with exposure, compound, and susceptibility)	Intestinal illnessess; taste or odor	methemoglobinemia (blue baby disease)	Acute: vomiting, weakness, etc. Chronic: cancer, genetic or birth defect risks	Chronic: adverse effects on blood, nervous and kidney systems	Chronic: cancer risks; taste or odor
Possible Source	Surface or shallow subsurface water or wastewater	Fertilizer, manure septic system, etc.	Improper use, disposal, spills or backsiphoning accident	corrosion of lead pipes or lead solder	Leaking storage tanks, spills, improper use or disposal
Suggested Treatment	Eliminate source; correct defects of well or supply, shock chlorinate, then recheck for safety	Eliminate source; correct defects of well or supply, anion exchange, reverse osmosis, distillation	Eliminate source, purge system; depending on type of pesticide, treatment units may be available (consult manufacturer)	Reduce corrosion, (see below), lead pipe/solder replacement, reverse osmosis; distillation	Eliminate source, purge system; activated carbon filter in series; vented distillation

II. Problems That Usually Do Not Threaten Health

Contaminant	F. Iron or Manganese	G. Hardness	H. Iron Bacteria	I. Corrosion	J. Taste/Odor
Complaint	Rusty water; rust stains on sink or clothes; deposition inside pipes	Scale, soap scums, deposition inside pipes	Oily film on water; slime growth in water tanks or toilets	Metallic taste; greenish stains on faucets, sinks, leaking pipes	Rotten egg odor
Possible Source	Corrosion of iron pipes or these elements may be naturally present in aquifer	Dissolved calcium and magnesium from soil and/or aquifer	Present in iron-rich aquifer; introduced by contaminated drilling equipment	Corrosive water present in aquifer; "softened" water; incompatible metals in plumbing; aggressive water	Hydrogen sulfide gives water this odor; corrosion; sulfur bacteria NOTE: make sure odor is not due to Coliform bacteria problem (see I.A.)
Suggested Treatment	Water softeners for soluble (ferrous) iron; Iron removal units (green sand filter); reverse osmosis; distillation	Water softener (ion exchange); reverse osmosis; distillation	Shock chlorination; continuous chlorination to retard regrowth	Add corrosion control chemicals or sacrificial metal	Shock chlorination; green-sand iron filter; activated charcoal filters

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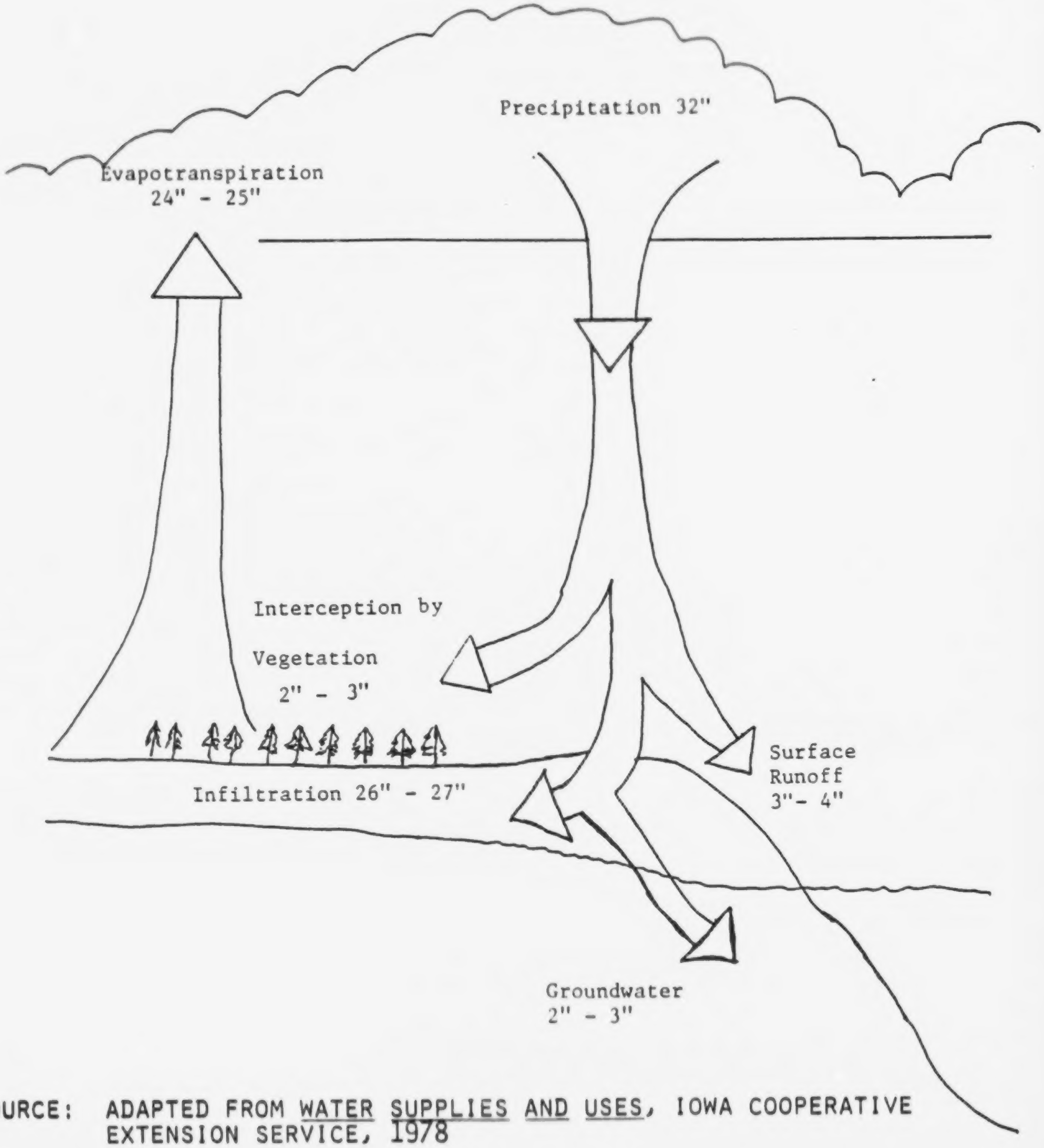
*The presence may indicate disease causing bacteria may also be present.

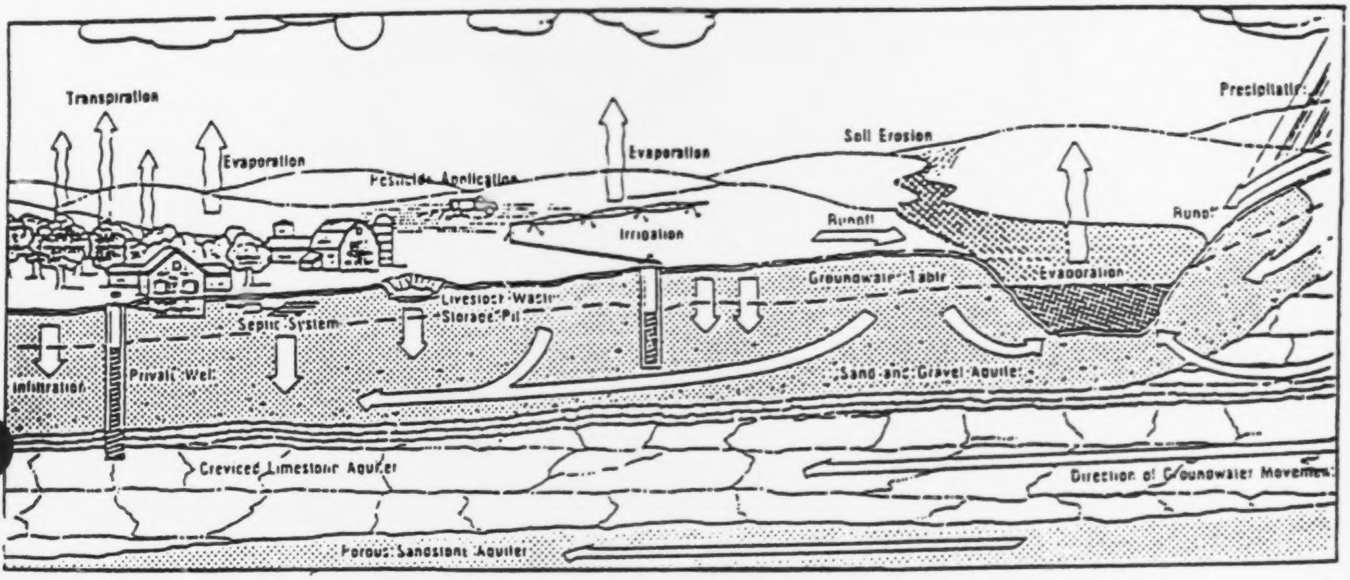
Water Quantity Relationships

Approximate Annual Iowa Water Budget


Precipitation 32"
Evapotranspiration
24" - 25"
Interception by
Vegetation
2" - 3"
Surface
Runoff
3"- 4"
Infiltration 26" - 27"
Groundwater
2" - 3"

SOURCE: ADAPTED FROM WATER SUPPLIES AND USES, IOWA COOPERATIVE EXTENSION SERVICE, 1978

Watershed and Land Surface Considerations In Water Quality


Transpiration
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Pesticide Application
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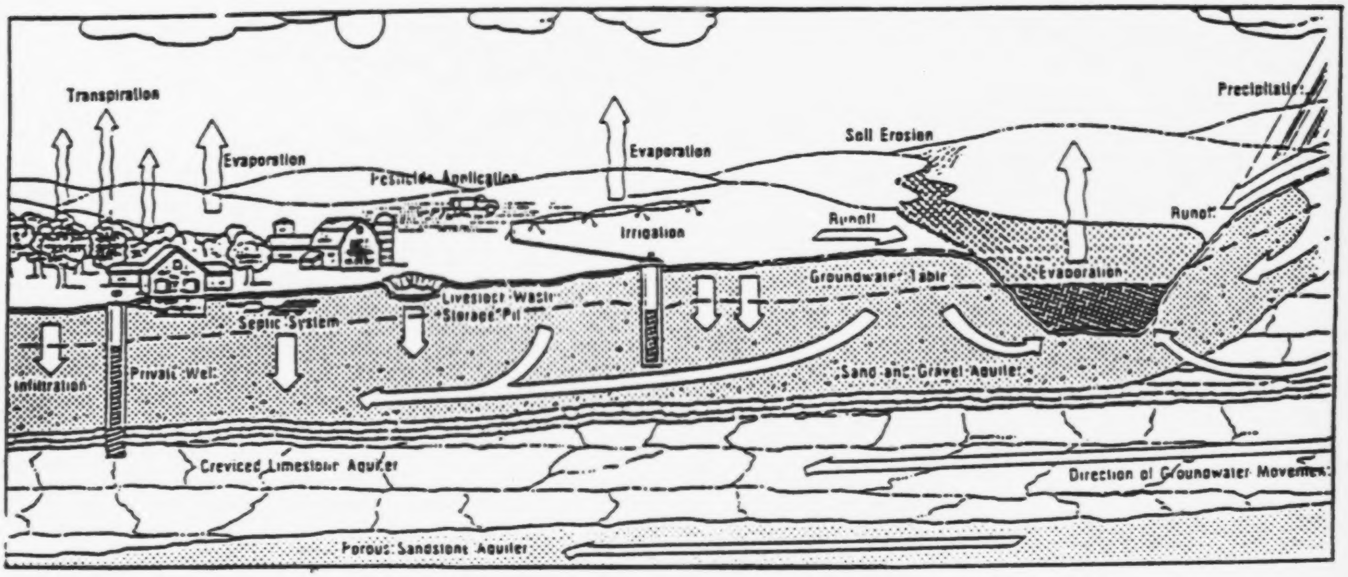
Soil Erosion
Precipitati
Runoff
Irrigation
Runoff
Groundwater Table
Evaporation
Livestock Waste Storage Pit
Septic System
Infiltration
Private Well
Sand and Gravel Aquifer
Creviced Limestone Aquifer
Direction of Groundwater Movemen
Porous Sandstone Aquifer

1. Define a Watershed.

2. Describe the factors in the illustration above that might influence water quality.

Watershed and Land Surface Considerations in Water Quality


Transpiration
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Groundwater Table
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Livestock Waste Storage Pit
Septic System
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Sand and Gravel Aquifer
Creviced Limestone Aquifer
Direction of Groundwater Movem
Porous Sandstone Aquifer

1 **Define a Watershed.**

- A watershed boundary follows the ridge of the land area which drains to a point, such as to a river or stream.

2 **Describe the factors in the illustration above that might influence water quality.**

- soil erosion from lack of plant cover or conservation practices.
- improper application of pesticides, fertilizers, animal wastes, wells, and septic systems.

Watershed Components Affecting Water Quality

The effect of a pollutant on receiving waters is determined by the quantity and nature of the pollutant, and by the characteristics of the receiving waters.

It is important to recognize: (1) the land/water interrelationships that affect the movement of substances in the living and non-living parts of the environment; (2) the physical, chemical and biological processes affecting water quality that occur naturally in streams, ponds, and lakes; and (3) the practicality of this knowledge as a basis for incorporating water quality considerations into conservation planning. How do the following factors and considerations affect water quality?

1. Temperature: ______________________________

2. Precipitation: ______________________________

3. Topography: ______________________________

4. Soils: ______________________________

5. Crc ng and/or Grazing Practices: ______________________________

6. Irrigation: ______________________________

Watershed Components Affecting Water Quality

The effect of a pollutant on receiving waters is determined by the quantity and nature of the pollutant and by the characteristics of the receiving waters.

It is important to recognize: (1) the land/water interrelationships that affect the movement of substances in the living and non-living parts of the environment; (2) the physical, chemical and biological processes affecting water that occur naturally in streams, ponds, and lakes; and (3) the practicality of this knowledge as a basis for incorporating water quality considerations into conservation planning. These factors and considerations are as follows:

1. Temperature: affects biological activity; plant nutrient uptake is reduced at lower temperatures.
2. Precipitation: directly affects the runoff of water and the detachment and transport of pollutants. Runoff will generally be greater if rainfall is of high intensity or if soil moisture levels are high. Hard rains may also carry chemicals to groundwater before they can be used by plants or decompose.
3. Topography: the capacity of water to detach and transport material increases with its velocity. The steeper the slope, the greater the velocity, and higher velocities promote erosion and inhibit infiltration. The pattern of drainage channels affect the delivery of pollutants to receiving waters.
4. Soils: infiltration rate of soils affects the ratio of surface flow to subsurface flow. The amount of organic matter, soil texture and soil structure determines the absorption capacity of the soil. Subsoil properties may either retard or enhance internal drainage.
5. Cropping and/or Grazing Practices: Crop cover and surface residue (cropping practices) protect the land from the impact of rainfall.
   Depending on the crop, longer growing periods and greater crop residue left on the soil reduces erosion.
6. Irrigation: methods and practices have a significant effect on the pollution potential of irrigated fields. The extent of irrigation water runoff and percolation losses depend on the accuracy of supplying the proper amount of water for the crop.

Source: Water Quality Field Guide, U.S. Soil Conservation Service

Understanding the Principle of a Contour Map Surface and Subsurface

In the study of the "Water Connection" we found that it is important understand both the earth's surface and subsurface features which contribute to the flow of water. Contour maps, or topographic maps, show the relative elevation (or height) of one geographic area to another as they exist on the earth's surface as well as geology features under the earth's surface.

Surface Features of the Earth

The following illustration represents a watershed area with contour lines.

Definitions:

(1) Watershed: an area of land where all the land surface drains into a common outlet or pond.

An example of this can be seen in our bathrooms. All the water falling from a shower into a bathtub runs into the drain. This represents the "tub watershed". All the water falling outside of the tub onto the floor moves to a different destination, thus it is outside the "tub watershed".

(2) Contour Line: this is a line on the map that connect all points with the same elevation.

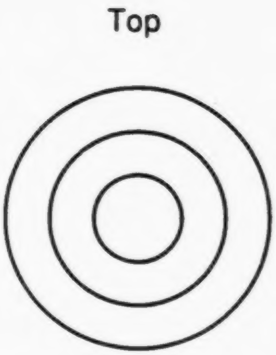
With reference to the "tub watershed", the soap ring that is left on the sides of the tub could represent a contour line (a line that connects all points of equal elevations.) Contour lines are drawn at different intervals depending on the scale of the map and its intended use. For example, this map has contour lines drawn at 10 foot intervals (10', 20', 30', etc.). Contour lines are determined by using a hand level, or various types of engineering levels, and then transferring these measurements to a map.

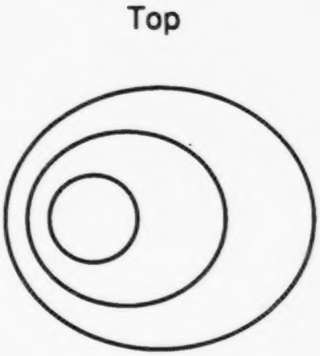
See ACT-HYDRO-3 (insert) for a simple illustration of a 3-dimensional contour line illustration.

In order to follow the flow of water on the earth's surface, we must draw in the watershed boundary to identify the direction of water movement. The following drawing on ACT-HYDRO-3 pg.2 illustrates how one would draw a watershed boundary from a contour map.

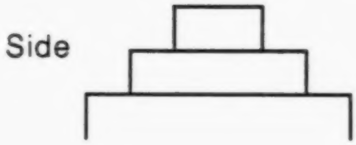
CONTOUR MAP DEMONSTRATION

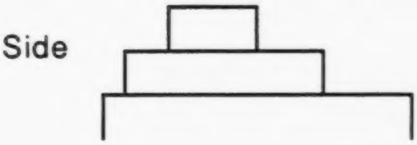
The teacher can make a simple 3-D model using stiff paper or poster board. Cut 3 circles of different sizes, and 3 one-inch wide strips -- one to go around each circle. Tape the strip to each circle. Each circle represents a contour line, and they can be stacked in different ways so the students can see the top and side views.





Which side is steeper?

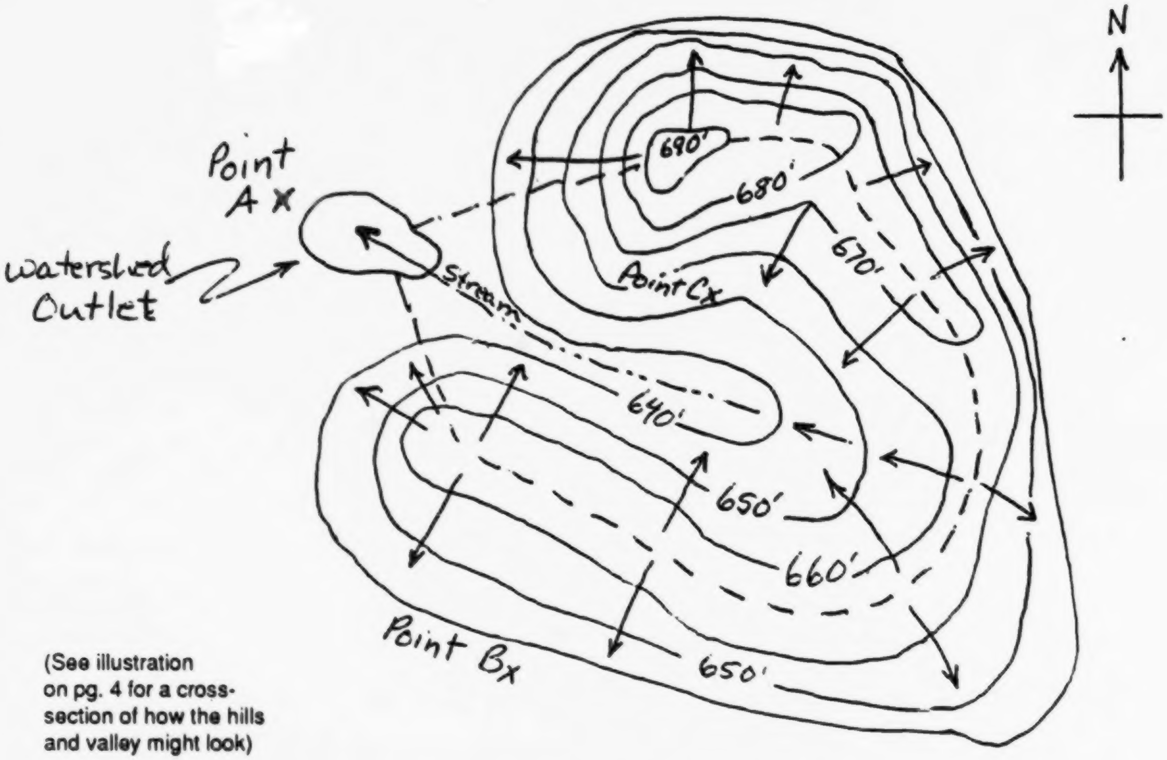




Concentric Rings = Hill

Left Side -- The closer the lines, the steeper the slope

- Find the highest points around the rim or ridge (which controls the flow of water into the watershed.) A dashed line has been drawn to connect these points and show the watershed boundary.
- arrows indicate the direction of water flow
- the direction of flow through the outlet of this watershed is to the Northwest.
- Points A, B, and C are used to compare the same points on the surface watershed with the subsurface basin on the next page. Contaminants polluting surface water at Point C would flow past Point A.



(See illustration on pg. 4 for a cross-section of how the hills and valley might look)

(Compare this to a contour map of an underground basin)

Water Movement Under the Earth's Surface (aquifers)

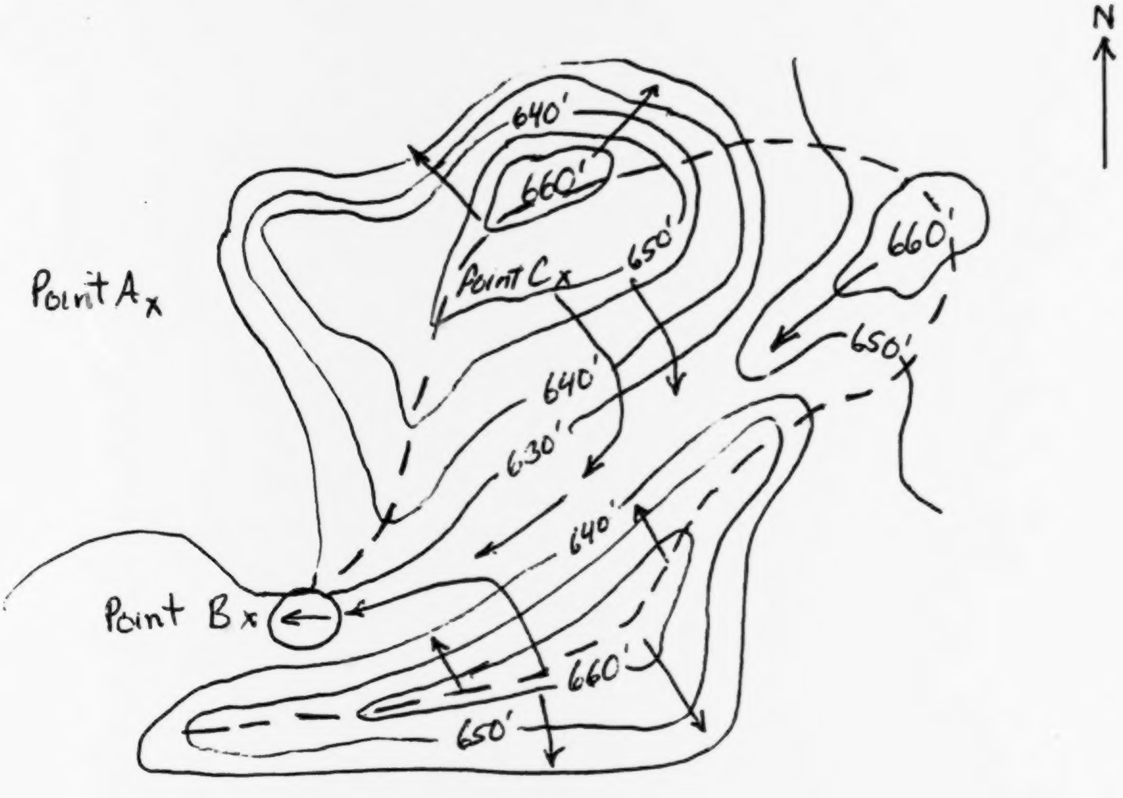
The direction of the flow of groundwater may be different from the direction of the 'surface water' flow. (One can't look at the roof of a house and determine what is happening in the basement).

Contour lines may also be used to connect equal elevations of similiar materials in one or more aquifers. For instance, in this example, the contour map may be used to represent the elevation of bedrock which underlies the earth's surface. If the bedrock elevation controls the direction of the groundwater, then it might flow in an entirely different direction than the surface water.

With this concept in mind, let's now analyze what the contour map of this basin of bedrock might look like.

Subsurface Features

- dashed lines show the bedrock basin, boundary.
- arrows indicate the direction of water movement.
- shows that the direction of the groundwater flow in this bedrock aquifer is southwest.
- contaminants polluting groundwater at Point "C" would flow toward Point B .



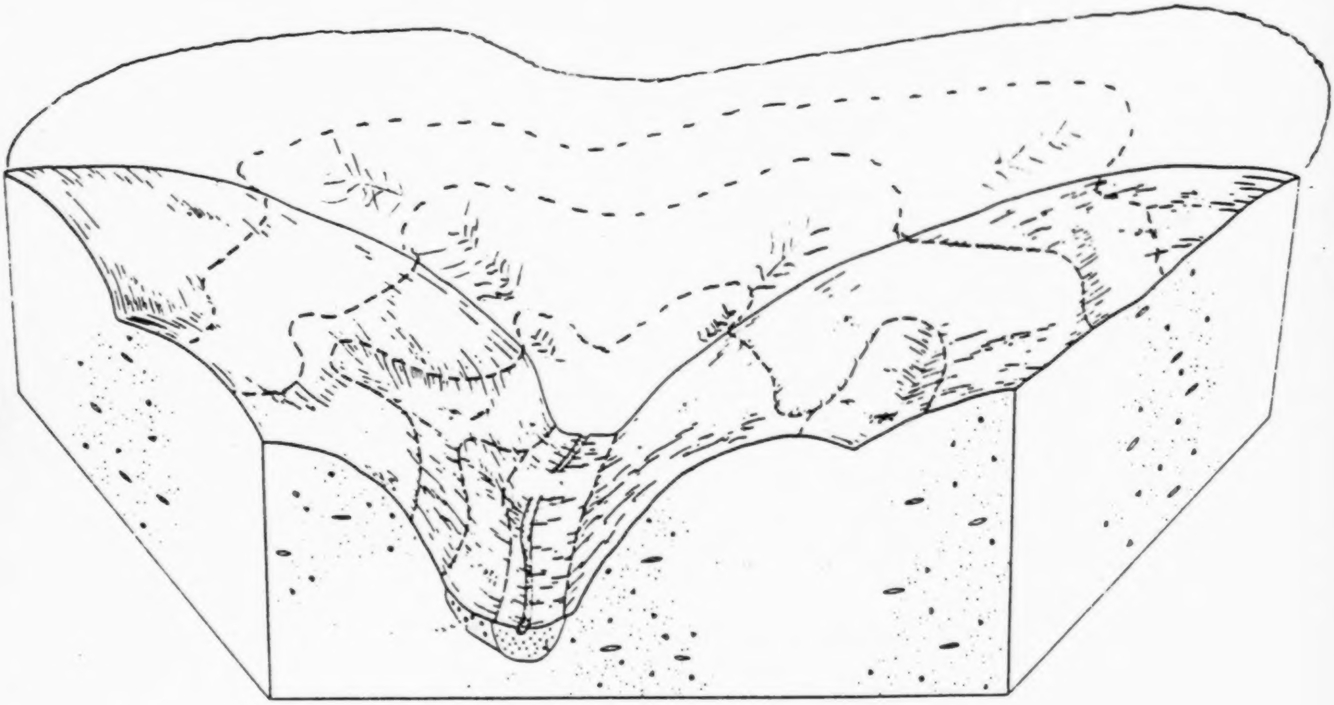
The comparison of these surface watershed and basin maps illustrates the point that some times there is not a direct correlation between the direction of the flow of surface water and the direction of the movement of groundwater. The features of the subsurface movement of groundwater is much more complex than the flow of surface water. Direction of groundwater flow not only is dependent on the contour of aquifer materials, but also on differences of energy levels and pressures (such as differences of elevation of the recharge area, in comparison to the discharge area).

Definition:

(1) Recharge Area: an area where groundwater is replenished with surface water.

(2) Discharge Area: an area where groundwater returns to the earth's surface in the form of a spring, or into a lake or river.

Cross Section View of a Watershed Area



*** for further information contact:

Geological Survey Bureau
Iowa Dept. of Natural Resources
123 N. Capital Street
Iowa City, IA 52242 (319) 335-1575

Contour Map Exercise

When a drop of water falls, it either infiltrates into the soil, evaporates into the air or runs along the top of the ground. Most water will eventually merge with a puddle, river, or lake. All the land area that drains water into a particular stream, pond or other body of water is called a watershed. A watershed can be as small as a patch of yard that supplies water to a puddle or as big as the Mississippi River Watershed that encompasses parts of several states and drains in the Gulf of Mexico.

Small watersheds make up larger ones. The Mississippi River, for example, drains a watershed of about 1,243,000 square miles. This large watershed is made up of thousands of smaller ones. Generally, watersheds are considered on a local or regional scale; the smaller streams that supply major watersheds are of a size that are manageable for most people. In fact, in many areas there are watershed associations composed of citizens working together to conserve the natural resources of a particular stream valley. Almost everywhere, people are concerned about various qualities of the environment where they live, work, or seek recreation. In maintaining and improving their surroundings, they also become aware that whatever happens in their local area is going to have some effect upon the people downstream.

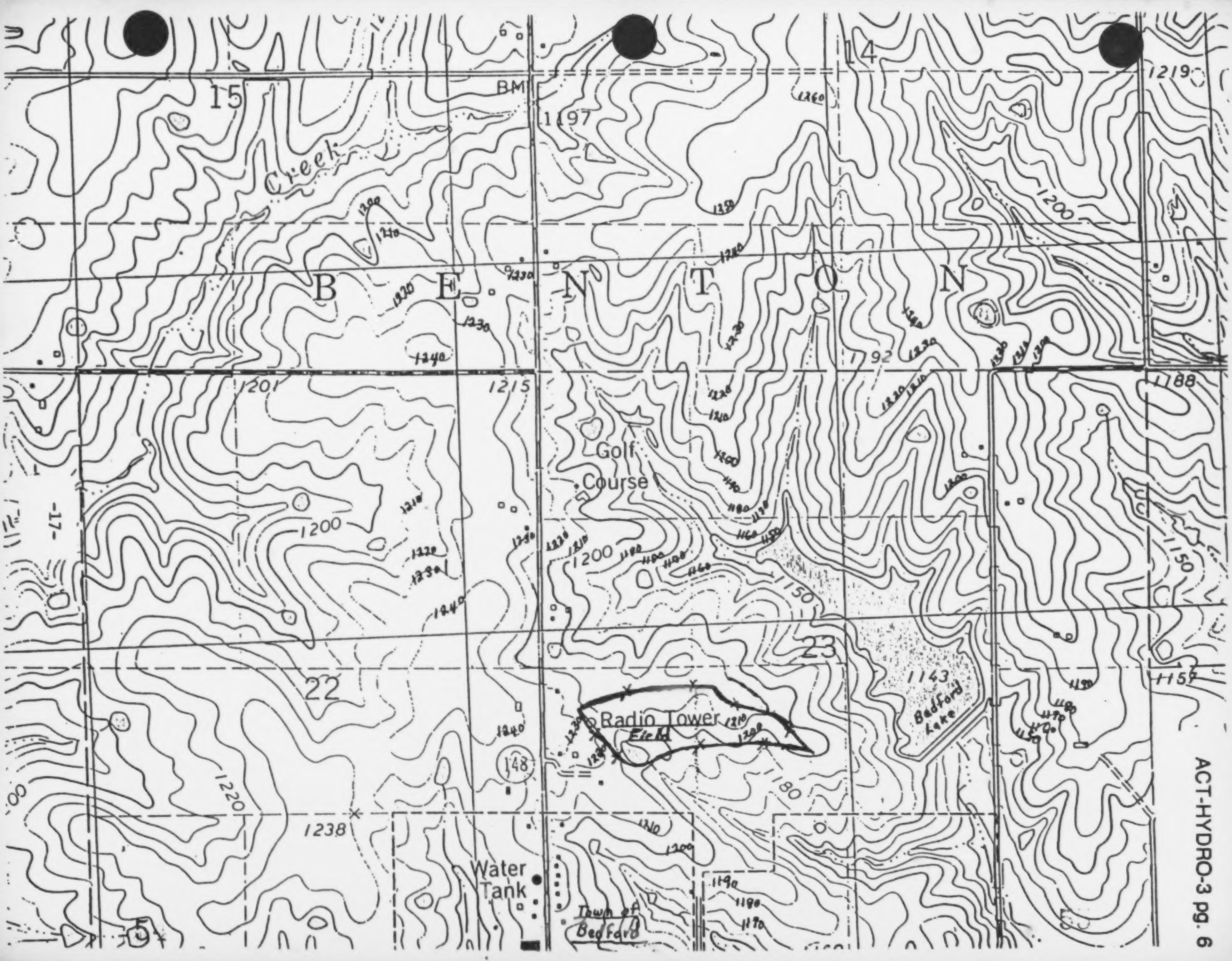
Questions

1. On the attached contour map draw in the watershed boundary around Bedford Lake. (The land that drains into the lake.)

2. Would sediment from the Radio Tower Field drain or wash into Bedford Lake? Place an arrow on the map showing the direction of water (sediment) flow.

3. Can pesticides or fertilizers from Radio Tower Field reach Bedford Lake?

*** This activity can be based on one of your local contour maps available from Iowa Geological Survey Bureau, 123 N. Capital St., Iowa City, IA 52242; of from the U.S. Geological Survey.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1188
17
Golf
Course
1180
1170
1160
1150
1200
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23
22
1143
Bedford
Lake
1157
1190
Radio Tower
Field
148
1238
1220
Water
Tank
Town of
Bedford
5

Contour Map Activity

Questions

1. On the attached contour map draw in the watershed boundary around Bedford Lake.

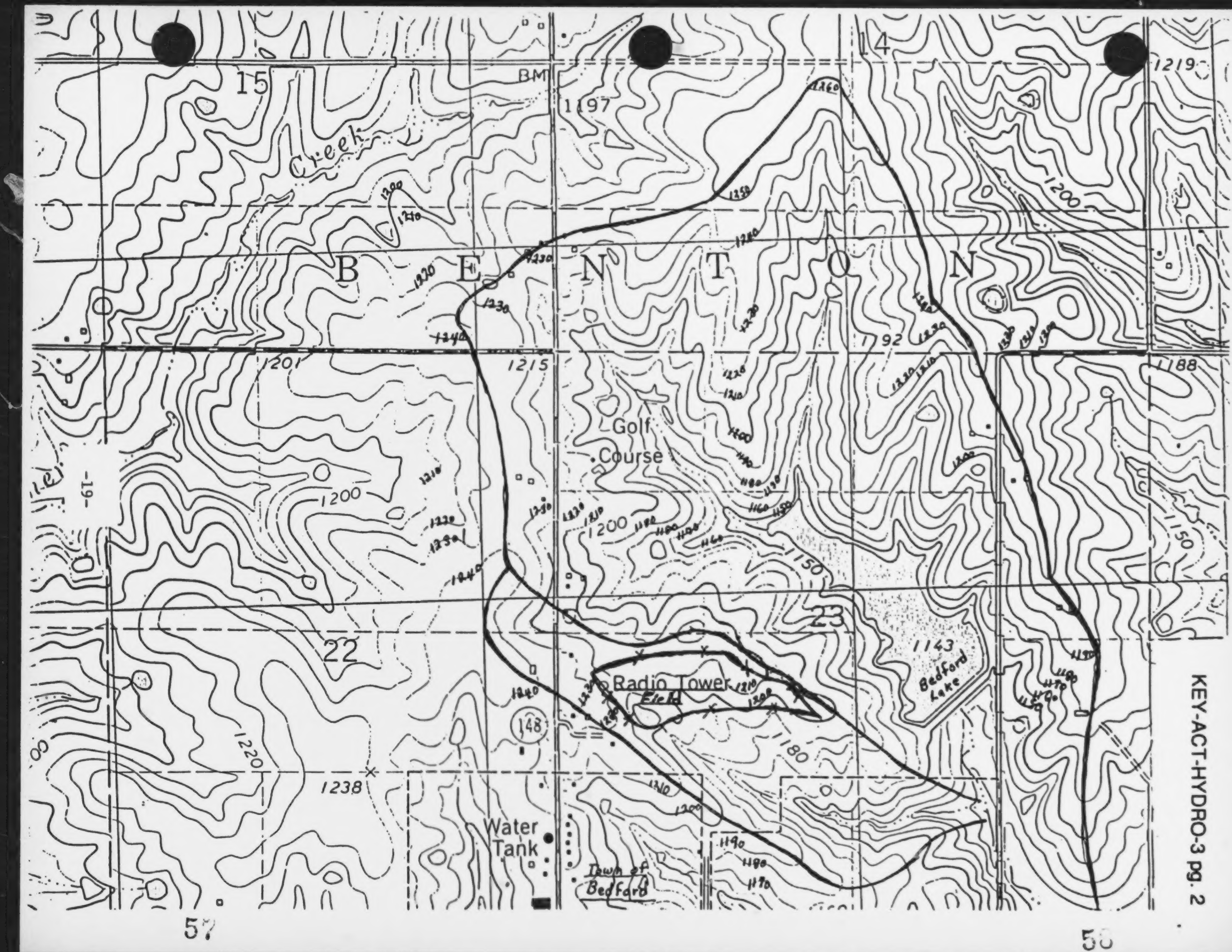
   - (see attached map) The watershed boundary is shown as a line representing the connection of the highest points on the topography within the Bedford Lake drainage area.

2. Would sediment from the Radio Tower Field drain, or wash, into Bedford Lake?

   - No, it would drain into the watershed to the left of Bedford Lake watershed.

3. Can pesticides or fertilizers from Radio Tower Fields reach Bedford Lake?

   - It is possible if they were dissolved in water and leached to the water table within an aquifer that discharged into Bedford Lake. The chemicals could then emerge later as surface water in the lake.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Golf Course
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1200
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1170
1160
1150
22
23
1143
Bedford Lake
Radio Tower
Field
148
1180
1238
Water Tank
Town of Bedford
57
58

KEY-ACT-HYDRO-3 pg. 2

Groundwater Questions

These questions can be answered by participants as the groundwater flow model is demonstrated or while the video is shown. In answering questions 1-3, refer to the Groundwater Flow Model.

1. Does groundwater often come from nearby sources? Where does the water you drink come from? Is it old or new water? How is this water source recharged?

2. Does most of our water come from underground lakes and rivers?

3. What controls the direction of flow of groundwater?

4. How is groundwater related to surfacewater? (recharge and discharge)

5. How do aquifers vary in texture (make up)?

6. What is the water table?

7. How can the direction of groundwater flow be checked?

8. What is the concept of a spring, and is it always pure water?

9. What causes an artesian aquifer? Where are recharge areas located?

10. Explain how water flows in an aquifer taking the least path of resistance.

11. Does the withdrawing of water from a well change the slope of the water table, and can it interfere with your neighbors well? Why?

Principles of Groundwater Flow

Hydrologic Properties of Soil and Rock

Water Storage Capability

Earlier we defined an aquifer as a volume of material with capacity to store and transmit water. First, let's consider the storage aspect.

Almost all earth materials have the capability of storing water. In unconsolidated sediments and soils, most of the storage space is found between the individual particles in pore spaces. In denser consolidated rock, the available storage space is usually in cracks or fractures. There are, of course, exceptions to this rule and these will be discussed later. For now it's sufficient to view rock and soil as semi-rigid skeletons containing various amounts of open void space.

Porosity. The amount of pore space in a particular type of earth material is highly variable and depends upon several different factors. The percentage of the total volume of material which is void space is called the porosity, and it is the key factor in determining how much water an aquifer can hold.

Now, how do you measure porosity? There are several scientific ways of doing it, but for the sake of understanding it, a simple example will do. Let's say you take a 5 gallon bucket and fill it with marbles that are all the same size. To determine the amount of pore space within this volume of marbles, slowly pour water into the bucket until it starts to come out of the top. How much water did it take? What percentage is that volume of the total bucket volume? If it took 2½ gallons of water, then that is half the volume of the bucket and represents a porosity of 50 percent. This is a pretty high porosity compared to most natural conditions. This degree of porosity, however, may exist in extremely uniform materials such as glacial sands and gravels, wind-blown sands, and beach deposits.

Factors That Control Porosity. Three factors that control the amount of pore space in an aquifer are: sorting, packing, and the shape of the individual soil or rock particles. You must understand that porosity is independent of the size of the particle involved. That is, you could take a room and fill it with bowling balls that were all the same size and you would have the same porosity as if you filled the same room with ping pong balls.

A mixture of different-sized particles in a single space, however, will influence the degree of porosity. This brings us to the next factor which is sorting. Sorting refers to the uniformity of size of the soil or rock particles. Some materials are made up of masses of particles that are uniform in size. Certain sandstones and unconsolidated glacial sands and gravels are good examples of well sorted materials. Glacial till, on the other hand, is a poorly sorted material. It is made up of different sizes of materials mixed together: sand, gravel, clay, silt, boulders and rock flour, the powdery remains of pulverized rock.

Unsorted or poorly sorted materials will always have lower porosities than well sorted materials. In unsorted materials the smaller grains can actually fill in the spaces between the larger materials, thus reducing the porosity. In other words, the greater the range in the particle size, generally the lower the porosity.

The second factor affecting porosity is packing. How the different particles are arranged has a great deal to do with the porosity of a material. Let's say you take that room full of bowling balls and arrange them in a cubic pattern so that the bottom of each bowling ball rests on the top of the one below it. If this is done throughout the room, you would have what is known as cubic packing. The associated porosity would be relatively high, approaching 48 percent.

If you arrange the bowling balls in a slightly different manner so that each bowling ball rests in the crevice of the four bowling balls below it, then you would have what is known as rhombohedral packing. The associated porosity of this kind of arrangement is about 30 percent.

The shape of the individual particles and their degree of rounding will also influence how a material can be packed. Well-rounded grains will pack together in a cubic or rhombohedral manner and angular, less weathered materials such as talus, broken pieces of rock at the base of a steep slope, will fit together more closely, resulting in lower porosities.

Primary porosity represents the pore space that exists between the individual grains making up a mass of rock or soil. It results from the way in which the material was originally deposited or formed. Unconsolidated beach sands, glacial deposits, soils and consolidated sandstones often display this type of porosity. Primary porosity may be reduced with time when minerals carried in solution by flowing ground water precipitate out and form cement that hold the grains together and fill the pores.

Secondary porosity occurs as a result of solutioning and structural changes in a rock unit and can be responsible for the storage and movement of enormous amounts of water. Where there are fractures, joints or bedding planes in an aquifer, ground water can flow freely through these spaces. With time, especially in limestone, rock is actually dissolved along existing crack faces and openings, resulting in even larger flow routes. Subsurface caves, channels and fractures, in reality, act as pipes or conduits for ground water. In areas where such features exist, the determination of the amount of secondary porosity is extremely difficult even for the most experienced geologists. Although these features are most common and well-developed in consolidated rocks, they also occur in unconsolidated deposits as well.

Porosity of Different Earth Materials. Because the particles that make up different earth materials all vary in their individual characteristics, they will, of course, form aquifers with different porosities. As a general rule, because they are unconsolidated, soils have higher porosities than rocks.

Unconsolidated Sediments. The most common types of unconsolidated earth materials are wind blown deposits (loess and dune sand), glacial drift (till, sand and gravel, clay and silts), saprolites or residual soils, alluvium (stream deposited sands, gravels, silts and clays) and lacustrine deposits (lake sediments). There is a wide range of porosity values for these types of materials, depending on how they are packed and sorted. Figure 4-3a lists the hydrologic properties of various unconsolidated sediments and their relative porosity ranges.

Although most clays and clay-rich materials seem quite dense, they may, in fact, have enormous porosities and hold a great amount of water. This is usually because of the size and the shape of the individual clay particles. Often clay particles are rod-shaped or almost book-shaped and have a polarity that tends to make them repel each other when closely packed, thus creating more pore space.

Consolidated Rocks. Now, what about porosity in consolidated materials? We'll start with sedimentary rocks. These rocks may be formed from unconsolidated sediments that are compacted and consolidated by the pressure of the overlying materials. They also may be formed by reactions with fluids in the pore spaces. Consolidation almost always reduces the porosity of the original material. With weathering and time, secondary porosity may occur along joints, fractures, solution channels and bedding planes. This increases the capacity of these rocks to hold water. The reduction of pore space is a result of precipitation of such cementing materials as calcite, dolomite or iron within the pore spaces and of the compaction which rearranges the individual particles.

Porosity in sedimentary rocks can range between 1 to 30 percent. Porosity of certain uniform, clean sandstones can run as high as 30 to 35 percent; some tight dolomites or limestones may have porosities in the range of 0 to 20 percent. Terrains which have well developed subsurface drainage through caves and solution channels are called karst. Remember, in Chapter 1 when you were warned against getting carried away with the underground river idea? Well, in karst areas such features often exist. Porosities can be high—anywhere from 5 to 50 percent. On the other hand, certain sedimentary rocks, such as shale, have porosities in the range of 0 to 10 percent. Figure 4-3b lists the hydrologic properties and porosities of different sedimentary rocks.

Source: Principles of Groundwater for Resource Management Systems, SCS Field Level Training Manual.

ACT-HYDRO-5

Basic Concepts and Processes

An understanding of the following concepts and processes is necessary for effective Resource Management Systems planning:

The Water Budget

The term "water budget" is routinely used in planning irrigation water application. Water budgets can also be used to evaluate the movement of water from all sources (precipitation or precipitation and irrigation). The water budget is an accounting method that can be used to determine how soil-water-plant relationships influence the movement of water from a particular site, and potential routes of pollutant movement associated with water.

Planners of resource management systems must understand how these soil-water-plant relationships (see VM-HYDRO-3) can affect pollutant movement. All precipitation and irrigation waters are inputs to the water budget. All water inputs must either go to runoff or infiltration. Minor quantities of water evaporate from the soil surface during precipitation and irrigation. These losses have an insignificant effect and are not considered in this discussion.

When one part of the budget is changed, other parts of the budget will be affected. The following equations describe the water budget process:

Equation 1. *Precipitation + Irrigation = Runoff + Infiltration*

In the precipitation equation, the increase of precipitation, irrigation water, or both, will increase the runoff, infiltration, or both.

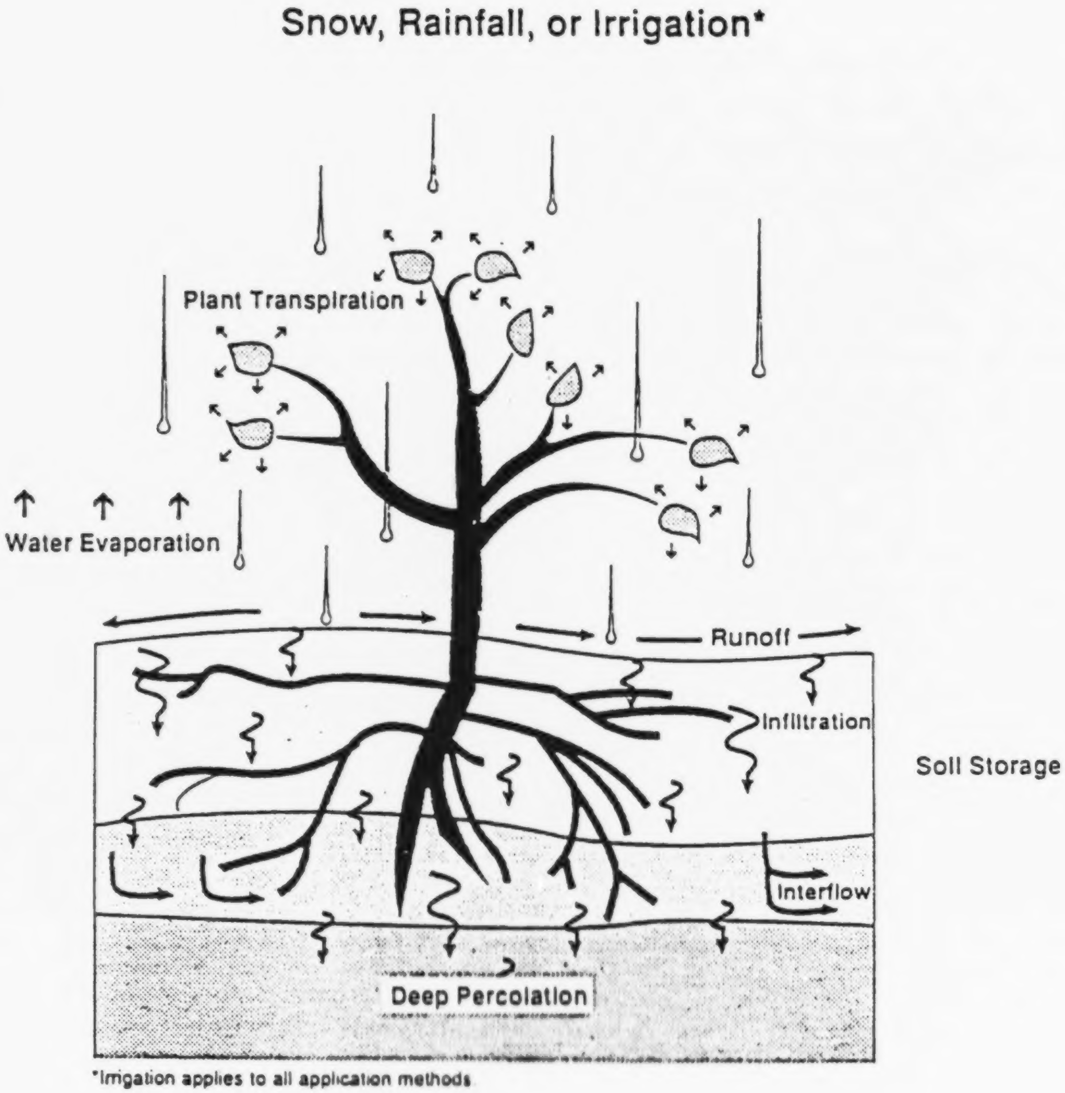
All infiltrated water must go to (1) soil storage, (2) plant transpiration, (3) evaporation, (4) interflow, or (5) deep percolation.

Equation 2. *Infiltration = Soil Storage + Plant Transpiration + Evaporation + Interflow + Deep Percolation*

In the infiltration equation, the increase or reduction of water use or movement in any of the budget categories will affect the remaining ones.

Source: Water Workshop, Integrating Water Quality and Quantity Into Conservation Planning, SCS.

Illustration of Soil-Plant-Water Relationship


Snow, Rainfall, or Irrigation*
Plant Transpiration
Water Evaporation
Runoff
Infiltration
Soil Storage
Interflow
Deep Percolation

*Irrigation applies to all application methods

Source: Water Workshop, Integrating Water Quality and Quantity Into Conservation Planning, SCS.

Role of Forests

Forests act as recharge areas.

Iowa was once 19% forested, but land clearing has reduced that to about 4% and forested land is continuing to decline. Many forests were removed from land that is too steep to farm. The removal continues to be greatest in the part of the state that has the least forest cover. (Prairies, pastures and standing crops can also be excellent recharge areas)

Characteristics of soils formed under forests and surface conditions vary from other areas. Some of these characteristics are listed below:

- organic matter is added from above
- A thinner A horizon (black topsoil layer)
- the forest floor contributes to a high rate of infiltration and percolation.
- in a well managed forest, more of the rain falling on the watershed infiltrates the soil, thus reducing overland flow and increasing percolation to GW (recharge).
- if the forest floor is destroyed, overland flow will increase reducing groundwater recharge.
- it should be noted that native prairies, wetlands, standing crops and pasture lands are excellent groundwater recharge areas also.

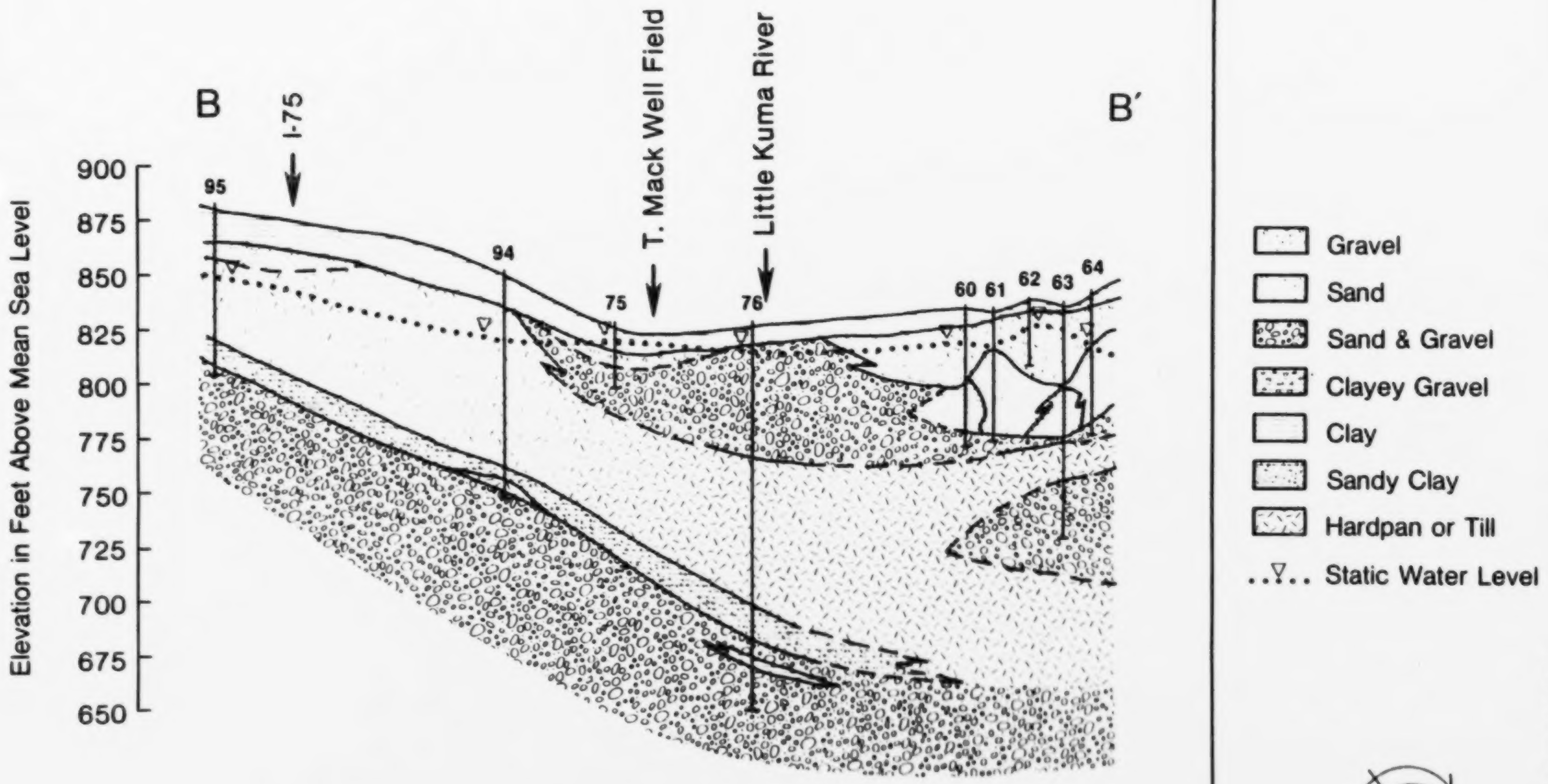
Forest ecosystems and wetlands provide excellent filters for cleaning surface and subsurface waters, as do prairies for surface-water.

- forest ecosystems have large permanent root systems that are active in water, nutrient and pollutant uptake for more of the year, than are other ecosystems.
- higher organic matter causes a soil structure that allows for higher rates of infiltration and percolation.
- nutrients and pollutants that are taken up by roots are held in tree trunks, branches, and leaves, and are then removed from the site when these trees are harvested.
- forests are an active storehouse for carbon-dioxide, thus acting to stabilize the "Greenhouse Effect." Trees remove CO_2 from the air.
- forest production allows the Iowa farmer to diversify because energy, fiber, timber, wildlife habitats, and erosion control are all provided by forests.
- wetlands are getting a new lease on life as a cleansing agent for ever-increasing wastewater.

Channelization influences residence time of water in a watershed.

- straightening of the channel reduces channel storage and increases velocity.
- reduced residence time means less GW recharge in the watershed and an increased potential for carrying more sediment and other pollutants out of the watershed.
- channelization reduces the filtering effect of bottomland forests.

** Information Source: Dr. Richard Schultz, Dept. of Forestry,
Iowa State University, Ames, IA 50010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775
750
725
700
675
650
Elevation in Feet Above Mean Sea Level
Gravel
Sand
Sand & Gravel
Clayey Gravel
Clay
Sandy Clay
Hardpan or Till
..▽.. Static Water Level

VM-HYDRO-4

schmidt associates

consulting geologists

Source: Principles of Groundwater For Resource Management Systems, SCS.

Alluvial Aquifers

Statewide

(Along Streams)

Contamination Potential is
High:
Alluvial Aquifers

Karst Areas

N.E. Iowa

(Localized)

Contamination Potential is
High:
Bedrock Aquifers
Low:
Deep Rock Aquifers

Shallow Bedrock

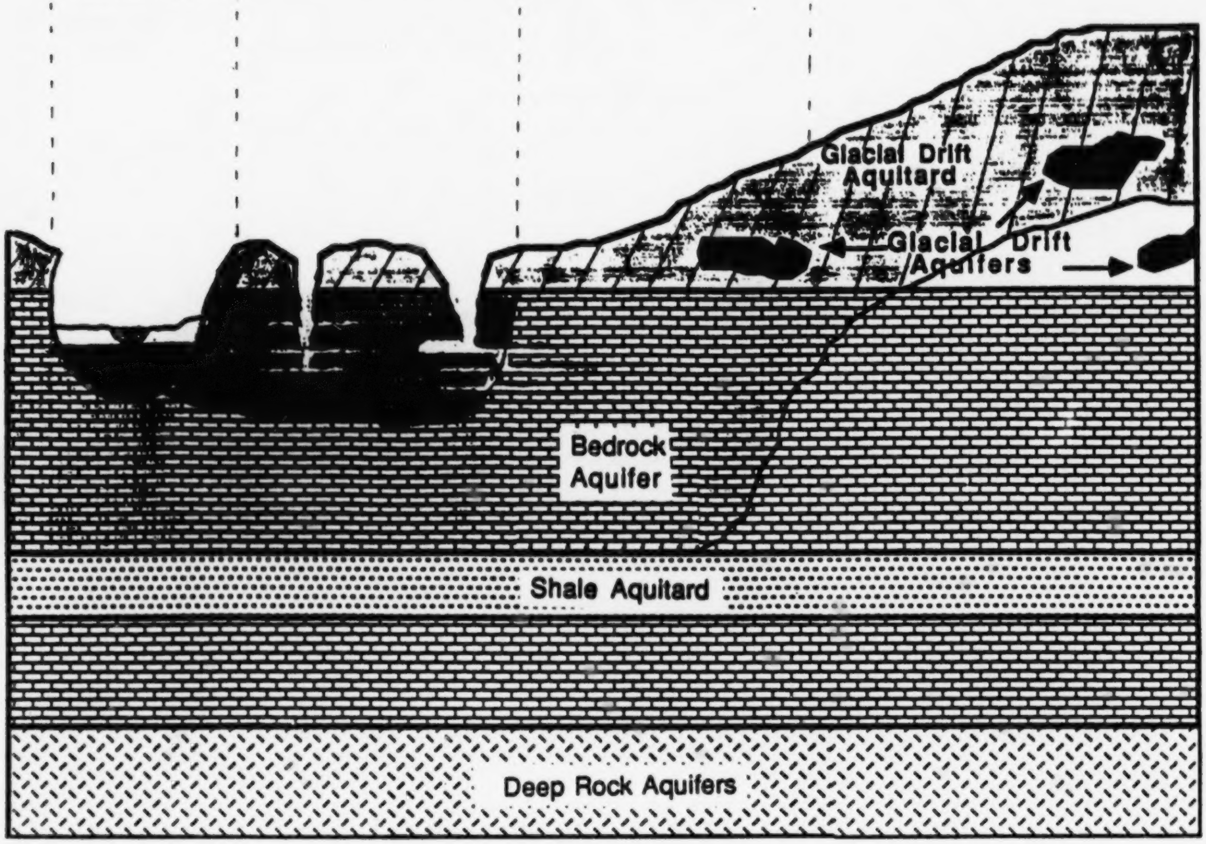
E. Iowa and Statewide

Contamination Potential is
High:
Drift Aquifers
Bedrock Aquifers
Low:
Deep Rock Aquifers

Shallow Drift Aquifers

Statewide

Contamination Potential is
High:
Shallow Drift Aquifers
Low:
Deep Drift Aquifers
Bedrock and Deep Rock Aquifers


Glacial Drift Aquitard
Glacial Drift Aquifers
Bedrock Aquifer
Shale Aquitard
Deep Rock Aquifers

Geological Conditions & Groundwater Contamination

▨ Zone of possible contamination from the infiltration of chemicals

☐ Zone generally free of contamination today

■ Zone of possible contamination from both infiltration and surface "run-in" of sediment, pathogens, and chemicals

Source: Iowa Geology, 1986, Iowa Geological Survey Bureau

Aquifers and Aquitards

Aquifers are saturated bodies of rock, sand or gravel from which water can be pumped for sustained periods of time. They are both porous and permeable and are highly variable in thickness and depth. Aquifers may be divided into four types:

(1) **Alluvial aquifers** are saturated sand and gravel deposits filling valleys along rivers and streams.

(2) **Drift aquifers** are saturated sand and gravel deposits which occur as regular and irregular bodies and are contained within a mass of clayey glacial drift. These aquifer deposits formed both within and upon glaciers.

(3) **Bedrock aquifers** are saturated bodies of rock.In Iowa these aquifers are usually limestone, dolostone, or sandstone. Often these aquifers cover vast areas.

Aquitards are bodies of rock which slow groundwater flow. They have low permeability and will not produce water from a well under normal pumping. They often separate aquifers and may even surround them. Generally, the higher their clay content, the more they will slow water movement. They can strongly influence both the direction and the rate of flow.

Highly susceptible to contamination are alluvial aquifers and bedrock aquifers in karst regions. Recharge through soils can be measured in days to years, and water quality in bedrock aquifers of karst regions can change on time scales measured in minutes and hours when surface water enters sinkholes. As aquitards get thicker, contamination responses are less likely to occur and contamination may not appear for years. Thus, shallow drift aquifers may reflect contamination in one area, but not in another because of slower contamination (water) movement where aquitards are thicker or less permeable. Deep bedrock aquifers are generally not contaminated except where major fracturing has occurred, where abnormal recharge has occurred because of major water withdrawals, or where poor well construction or improper well abandonment has taken place.

It should be noted that local water quality within an aquifer can vary greatly. No perfect prediction of contamination is possible. Natural water quality varies considerably throughout each state.

Natural Groundwater Quality

Iowa's natural groundwater quality varies considerably across the state. Groundwater commonly contains dissolved minerals such as magnesium, calcium, sodium, iron, fluoride, and sulfate. The problem with many natural contaminants is not safety, but aesthetics (taste, odor, or color). For example, high levels of iron can stain plumbing fixtures and laundry and give drinking water an unpleasant taste and odor.

As water percolates through the ground it dissolves some of the minerals in the materials it encounters, increasing its mineral concentration. Therefore, in general, **the deeper the aquifer, the more dissolved minerals it has, and the**

poorer the natural water quality. For example, the illustration below shows a generalized cross-section of the Jordan aquifer in Iowa tapped by two wells, one near Council Bluffs in the west and one near Dubuque in northeastern Iowa. In eastern Iowa, the Jordan aquifer is near the surface and has better natural water quality; but in western Iowa, the depth to the aquifer increases and the natural water quality becomes more highly mineralized.

Typically, the natural quality of groundwater found in alluvial aquifers is best. Drift aquifers and buried channel aquifers located throughout Iowa are highly variable in both water quantity and quality.

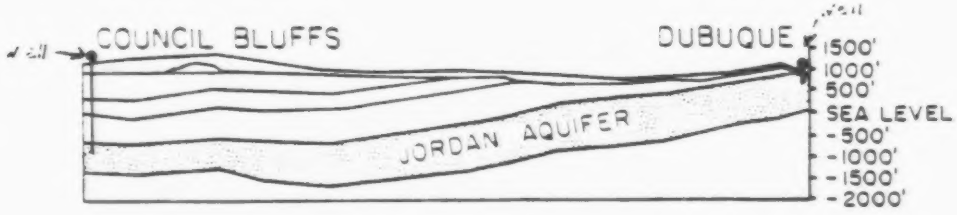
The natural quality of bedrock aquifers is good in northeastern and eastern Iowa and fair in northwestern Iowa. Southern Iowa generally has the state's poorest natural water quality.

Radioactive elements are other naturally occuring contaminants that are occasionally found in groundwater supplies. Generally, radioactivity is not a widespread problem in Iowa, but levels can be high in some rock aquifers, especially in northwest, central, and southeast Iowa, where levels may exceed state drinking-water standards.

In Iowa, natural water quality often mirrors water quantity. The best natural groundwater quality is generally in alluvial aquifers. Drift aquifers located throughout the state are highly variable in both quantity and quality. Often however, they provide good natural quality water adequate for domestic uses. Rock aquifers in northeast Iowa have good natural water quality. The bedrock aquifers in northwest Iowa have fair water natural quality.

Alluvial, drift, and shallow, unprotected bedrock aquifers are the most susceptible to contamination from sources of human activities. Alluvial and deep aquifers supply the greatest number of people with drinking water.

Source: Adopted from Iowa Geological Survey Bureau
Department of Natural Resources



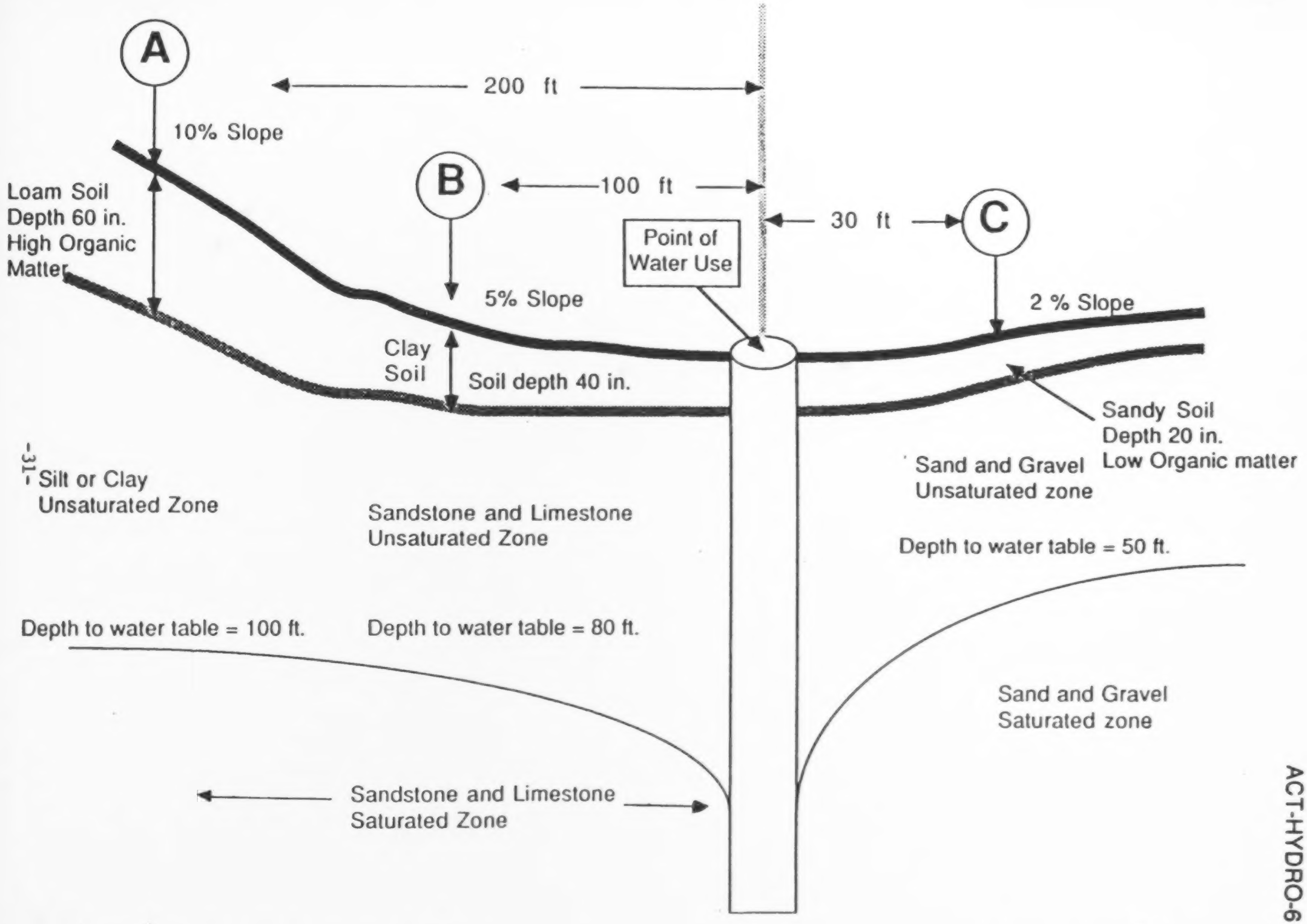
Site Selection Exercise

There are many factors which influence the behavior and movement of contaminants in the soil. Some of the more important factors are:

1. slope of the land,
2. soil characteristics (soil texture),
3. soil depth,
4. depth to water table,
5. texture of the unsaturated zone,
6. type of aquifer material (permeability),
7. the horizontal distance between the potential contamination source and the point of water use.

You have been hired as a consultant to evaluate which site; A, B, C would be the least likely to be a potential source of groundwater contamination from the application of natural fertilizers.

1. Which site would be the most apt to be a potential source of pollution and which site would be least likely to be a source of pollution?
2. Give detailed answers to support your choices.


A
200 ft
10% Slope
Loam Soil
Depth 60 in.
High Organic
Matter
B
100 ft
5% Slope
Clay
Soil
Soil depth 40 in.
30 ft
C
Point of
Water Use
2 % Slope
Sandy Soil
Depth 20 in.
Low Organic matter
Sand and Gravel
Unsaturated zone
Silt or Clay
Unsaturated Zone
Sandstone and Limestone
Unsaturated Zone
Depth to water table = 50 ft.
Depth to water table = 100 ft.
Depth to water table = 80 ft.
Sand and Gravel
Saturated zone
Sandstone and Limestone
Saturated Zone

Site Selection Exercise

A. Site C would be the most apt to be a potential source of pollution. Site A would be the least likely to be a source of pollution.

B. Reasons (Following are factors which influence the behavior and movement of contaminants in the soil.)

1. Land slope - The steeper the slope, the greater the water runoff and the less potential infiltration of groundwater. Site A has the steepest slope, site C is the flattest.

2. Soil texture - Medium textured, well-aerated soils like loam has the least pollution potential. Coarse textured soils such as sandy soils have the greatest pollution potential. Site A is composed of loam with high amounts of organic matter and site C is composed of a sandy soil with low organic matter.

3. Soil depth - The greater the soil depth, the better the chance of dispersing the pollutant as it passes through the soil and the less chance of the pollutant reaching the groundwater. Site A has the deepest soil depth and Site C has the shallowest soil depth.

4. Depth to water table - The greater the distance the pollutant has to travel to reach the water table the less chance for pollution. Site A has the deepest depth while site C has the shallowest.

5 and 6 Texture of the unsaturated zone and type of aquifer material - The greater the permeability, the greater the chance for groundwater pollution. Site A's unsaturated zone and aquifer materials are made of finer, less permeable materials while site C has the coarsest, most permeable materials.

7. Distance between the site and the point of water use - The greater the distance between the site and the point of use, the less the pollution potential. Site A is the farthest while site C is the closest.

Summary - In the evaluation of all 7 factors, in all cases site A had the least potential and site C the greatest.

This is only a simulation, but the principles apply to any site selection and all these factors should be used when evaluating a site and the potential pollution hazard that site has. (This evaluation should be made for any type of potential pollution source).

Principles for Presentations

Consider addressing the following principles in the Water Connection (Hydrogeology Module).

1. Groundwater- where it comes from, where it goes.

2. What images do you have visualizing groundwater?
   (could brainstorm to illustrate different perceptions)

3. Groundwater is not magical - it follows well-understood natural laws.
   It is hidden most of the time and occurs in an amazing range of conditions.

4. General characteristics of groundwater, earth's surface and water table.

5. Relationship of inputs verses withdrawal of groundwater; precipitation verses
   evaporation (a question of depleting the groundwater supply).

6. Where, and at what rate, does precipitation enter the ground?
   - where determines recharge zone, rate gives clue as to whether water is
   added faster than removal, with the potential for drying up.

7. Variation of quantity, quality, and movement of groundwater.

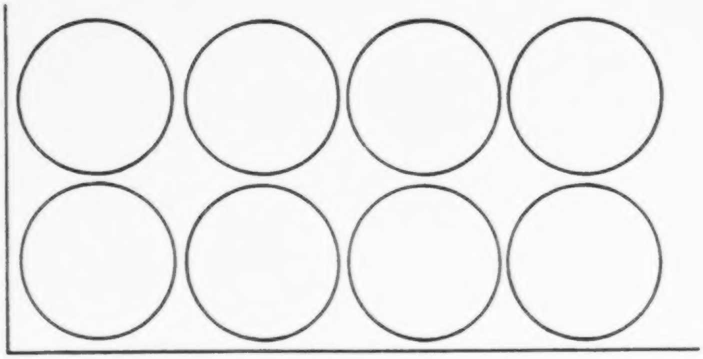
8. Potential for organic solvents breaking down clay minerals and destroying
   impermeable nature of confining beds.

9. Use, abuse, and pollution of groundwater is increasing worldwide.

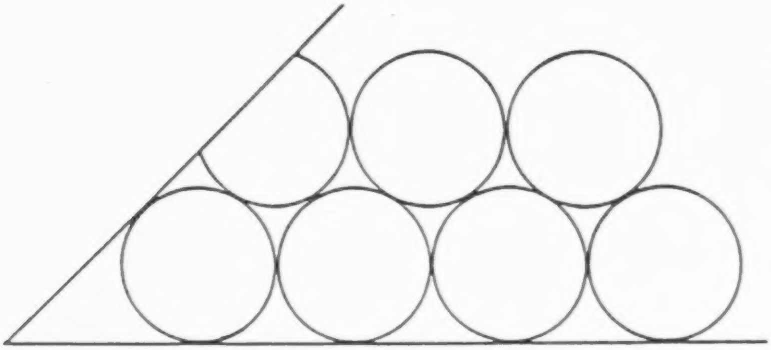
10. Groundwater pollution, much more difficult to "clean up" than surface water.
    Groundwater pollution is much easier to protect through prevention.

11. Solution of the problem must start at home.

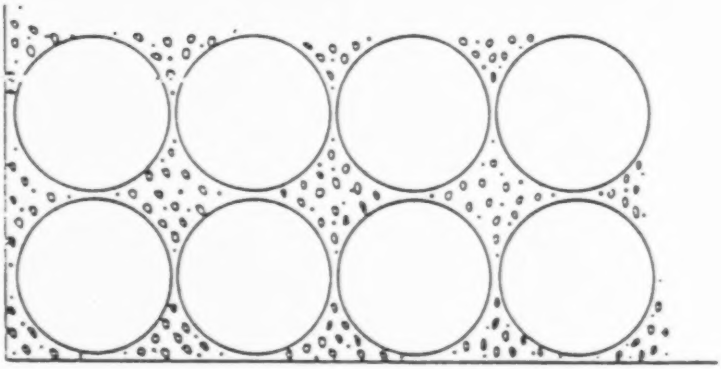
Soil Aeration and Porosity



Cubic Packing - Porosity = 47.65%



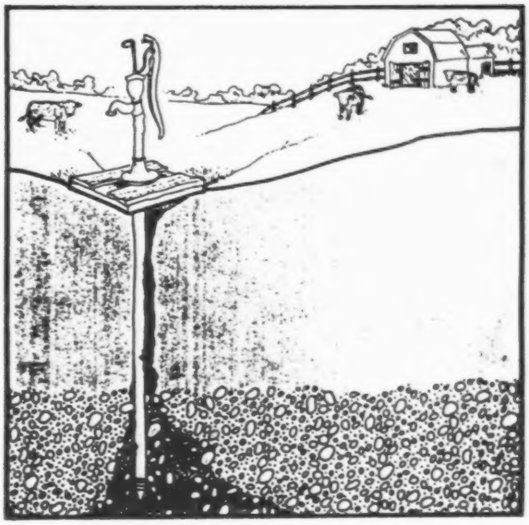
Rhombohedral Packing - Porosity = 29.95%

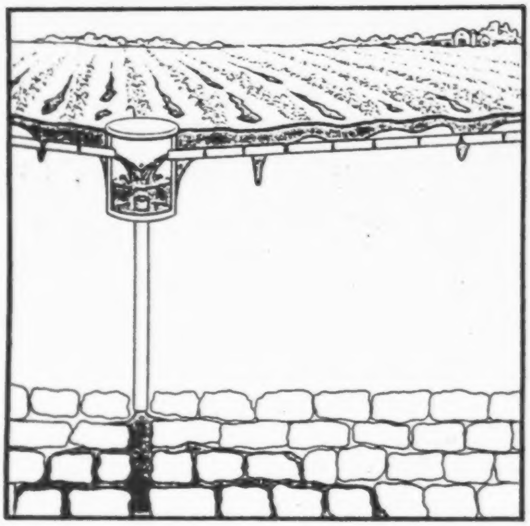


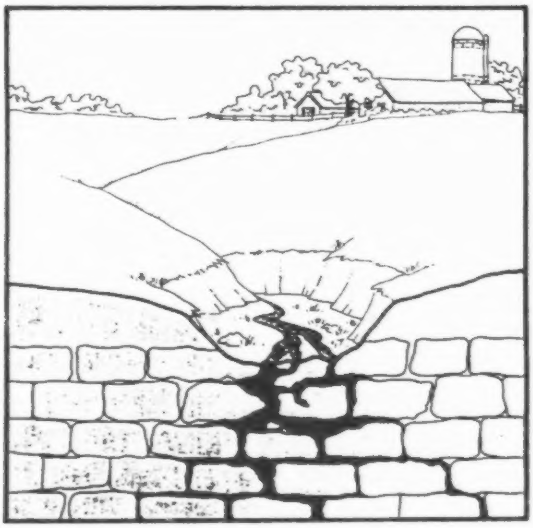
Unsorted mixture of Cubic Packed Grains
with smaller grains filling the void space
(Reduced Porosity compared to (A) above)
Porosity = 7 - 20%

Source: Principles of Groundwater For Resource Management Systems, SCS Field Level Training Manual.

LOCATING DIRECT CONNECTIONS







EDUCATIONAL CONCEPTS

- Definitions, regions and problems associated with agricultural drainage wells, abandoned wells and sinkholes

- Contamination, prevention and effects

Locating Direct Connections

LESSON 1: Identifying Direct Paths of Groundwater Contamination

GOAL:

Identifying groundwater entry sites and paths is the first step toward preventing groundwater contamination. All Iowa citizens need to know how to identify paths associated with groundwater contamination.

OBJECTIVES:

After completion of this lesson, the participants will be able to:

1. Analyze groundwater problems caused by sinkholes, abandoned wells, and agricultural drainage wells.
2. Identify where sinkholes, abandoned wells, and agricultural drainage wells are most commonly found in Iowa.

MATERIALS & REFERENCES:

Groundwater Flow Model or video, overhead projector, bread pans, sand, empty soup can with both lids removed, spoon, food coloring, water, sprinkler can and syringe, PM 1201 - Agricultural Drainage Wells in Iowa, Groundwater ow Model Manual

VISUAL MASTERS:

VM-PATHS-1	Maps of Iowa
VM-PATHS-2	Illustration of Karst area
VM-PATHS-3	Profile of a sinkhole
VM-PATHS-4	Profile of abandoned wells
VM-PATHS-5	Profile of Agricultural Drainage Well

ACTIVITIES:

ACT-PATHS-1	Direct Sources of Groundwater Contamination
ACT-PATHS-2	Experiment: Simulating Groundwater Contamination
ACT-PATHS-3	Local Safety Check
ACT-PATHS-4	Knowledge Analyzer

INFORMATION:

INFO-PATHS-1	Direct Sources of Groundwater Contamination

INTEREST APPROACH:

Use VM-PATHS-1 and the Groundwater Flow Model or video and ask:

(The lower map on VM-PATHS-1 is a relief map of Iowa reduced in scale. The original larger map was a contour map of Iowa. As the scale is reduced, the steeper areas appear black while the flatter areas of Iowa appear white. Note that the flatter area of north central Iowa is where the concentration of agricultural drainage wells are located).

1. How does the topography of the land differ in various parts of the state?
2. How does the topography of Iowa's land affect the contamination of groundwater? Use the top map on VM-PATHS-1 to show the primary location of agricultural drainage wells in Iowa. A route for contamination is drainage wells that collect water from farmland runoff. They funnel water directly into the groundwater system that is widely used as a source of drinking water. Use VM-PATHS-2 to emphasize that the Karst regions (sinkholes and caves) in northeast Iowa provide an easy path for water to enter into the groundwater system.

Prepared by Martin Frick, Department of Agricultural Education, Iowa State University, Ames, Iowa, June 1989.

Abandoned wells and cracked well casings, located throughout Iowa, are also a potential source of groundwater contamination. Emphasize the point that groundwater contamination is a problem that should be of concern to all Iowa citizens. Even though these direct routes for potential groundwater contamination exist, our greatest potential is through the indirect routes of soil infiltration.

TEACHING PROCEDURES:

1. Divide the class into groups and direct them in completing ACT-PATHS-1. Use INFO-PATHS-1 and PM-1210, Agricultural Drainage Wells in Iowa as references.

2. Direct the students in summarizing answers to the questions on ACT-PATHS-1. Use VM-PATHS-3, 4, 5 and the illustrations in PM-1201, Agricultural Drainage Wells in Iowa, to emphasize the three (3) direct paths for surface water to enter into the groundwater. Again point out that the greatest potential for groundwater contamination is through excess moisture moving field applied chemicals through the soil.

3. Involve students in an experiment (ACT-PATHS-2) to simulate groundwater contamination and illustrate that it's much wiser to prevent groundwater contamination than to clean it up once it's been polluted.

4. Use ACT-PATHS-3 to organize and carry out a local safety check to identify direct paths of groundwater contamination.

5. Use the groundwater flow model or video to demonstrate contamination through sinkholes, abandoned wells and agricultural drainage wells.

6. Assess student's knowledge of direct paths of groundwater contamination and related concepts using ACT-PATHS-4 (Correct answers are as follows: 1=F, 2=T, 3=T, 4=F, 5=T, 6=F, 7=F, 8=F, 9=T, 10=T).

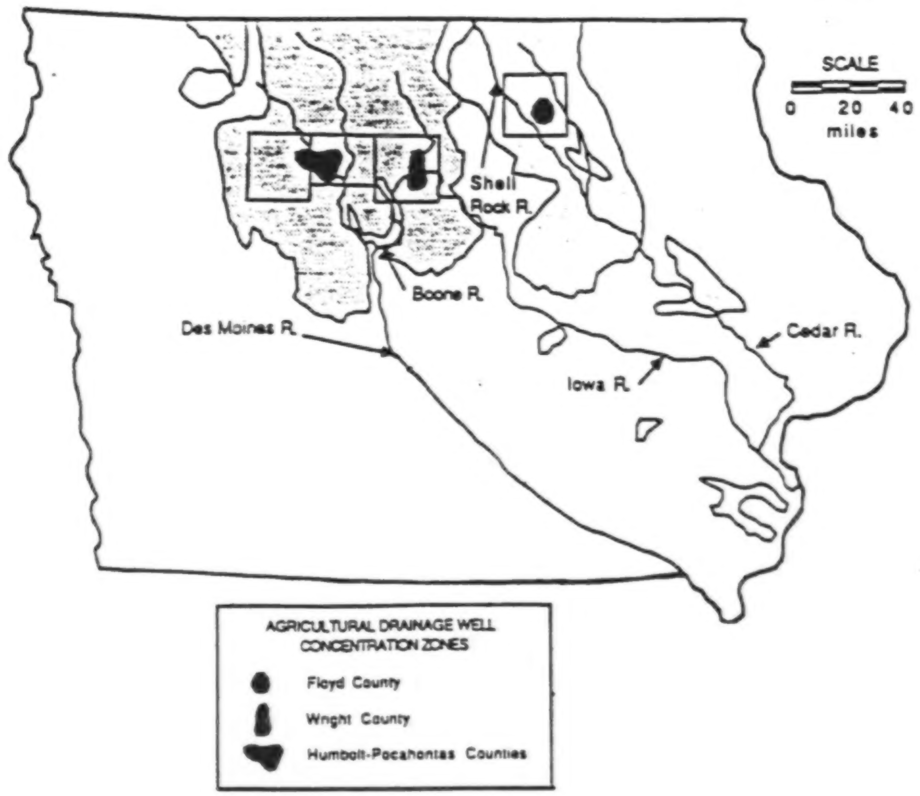
OTHER ACTIVITIES:

Using plaster of paris, simulate different types of topography that occur throughout Iowa (karst, loess hills, prairie, alluvial plains, etc). Direct paths (agricultural drainage wells, sinkholes, abandoned wells) may be designed to illustrate possible causes of groundwater contamination.

SUMMARY:

Sinkholes, abandoned wells and agricultural drainage wells are potential direct paths of groundwater contamination; however, contamination through the soil surface is the greatest potential path in total volume of agricultural contaminants. Remember: Iowa's groundwater problems affect every citizen in the state.

IOWA


SCALE
0 20 40
miles
Shell Rock R.
Boone R.
Des Moines R.
Cedar R.
Iowa R.
AGRICULTURAL DRAINAGE WELL CONCENTRATION ZONES
Floyd County
Wright County
Humbolt-Pocahontas Counties

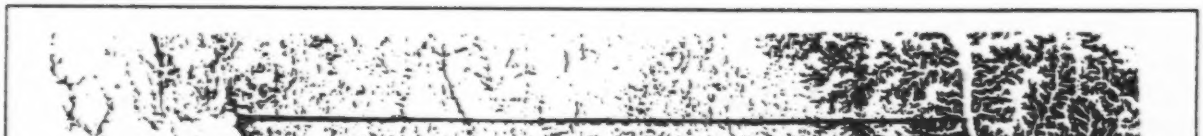
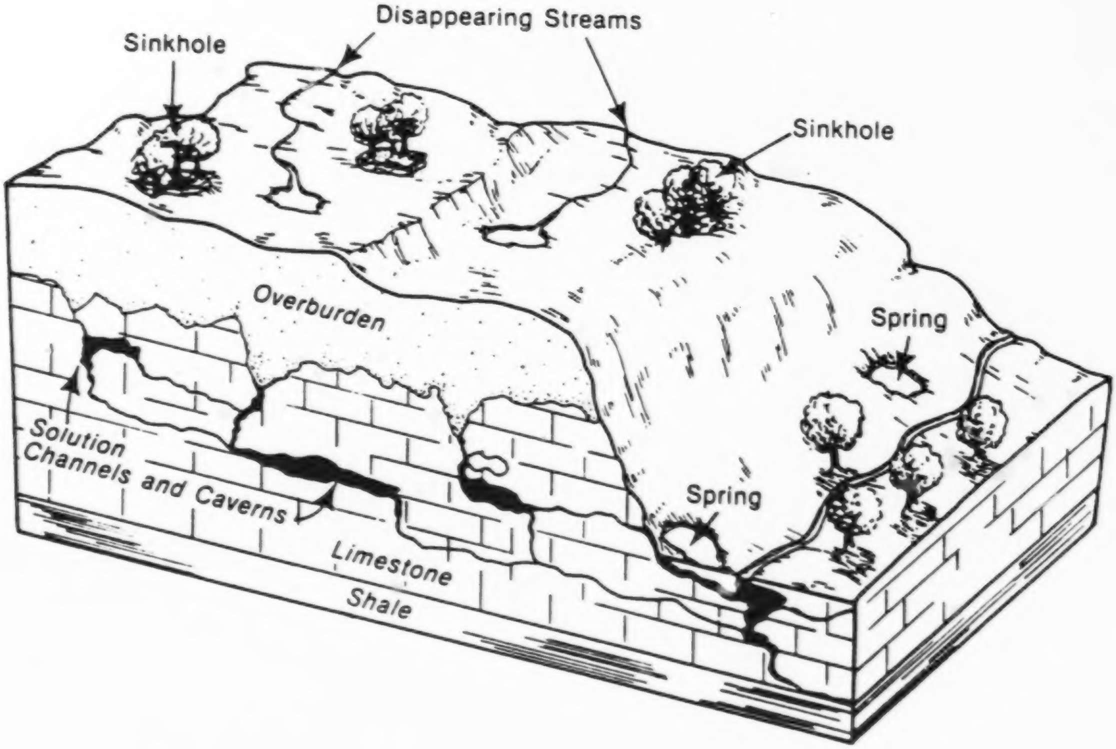

RELIEF MAP OF IOWA

ILLUSTRATION OF THE KARST AREA


Sinkhole
Disappearing Streams
Sinkhole
Overburden
Spring
Solution Channels and Caverns
Spring
Limestone
Shale

Karst features.

DIRECT SOURCES OF GROUNDWATER CONTAMINATION

1. What are sinkholes? Where are they primarily located in Iowa?

2. What are abandoned wells? Where are they primarily located in Iowa? Do you know of any in our community? Are there any dangers?

3. What are agricultural drainage wells? Where are they primarily located in Iowa? Do you know of any near our community?

4. In general, what type of land topography describes your local area and how does it affect the quality of the drinking water?

DIRECT SOURCES OF GROUNDWATER CONTAMINATION

Sinkholes

Sinkholes are natural depressions and openings in the land surface. They generally occur in limestone regions formed by rainwater dissolving the limestone rock resulting in caves and unsupported surface material. As the caves collapse, sinkholes are formed allowing surface drainage to directly enter the groundwater supply. Sinkholes are primarily located in northeast Iowa where cave systems are most prevalent.

Abandoned Wells

The Iowa Department of Natural Resources defines an abandoned well as follows: "Abandoned well means a water well which is no longer in use or which is in such a state of disrepair that continued use for the purpose of accessing groundwater is unsafe or impracticable."

They are located throughout the state. There are thousands to be found on farmsteads and in communities around the state. Wells that have been replaced by community water treatment and distribution systems still adorn lawns in many communities. Besides being a source of groundwater contamination, abandoned wells are a safety hazard. A large well casing is wide enough to allow a young child to fall into it.

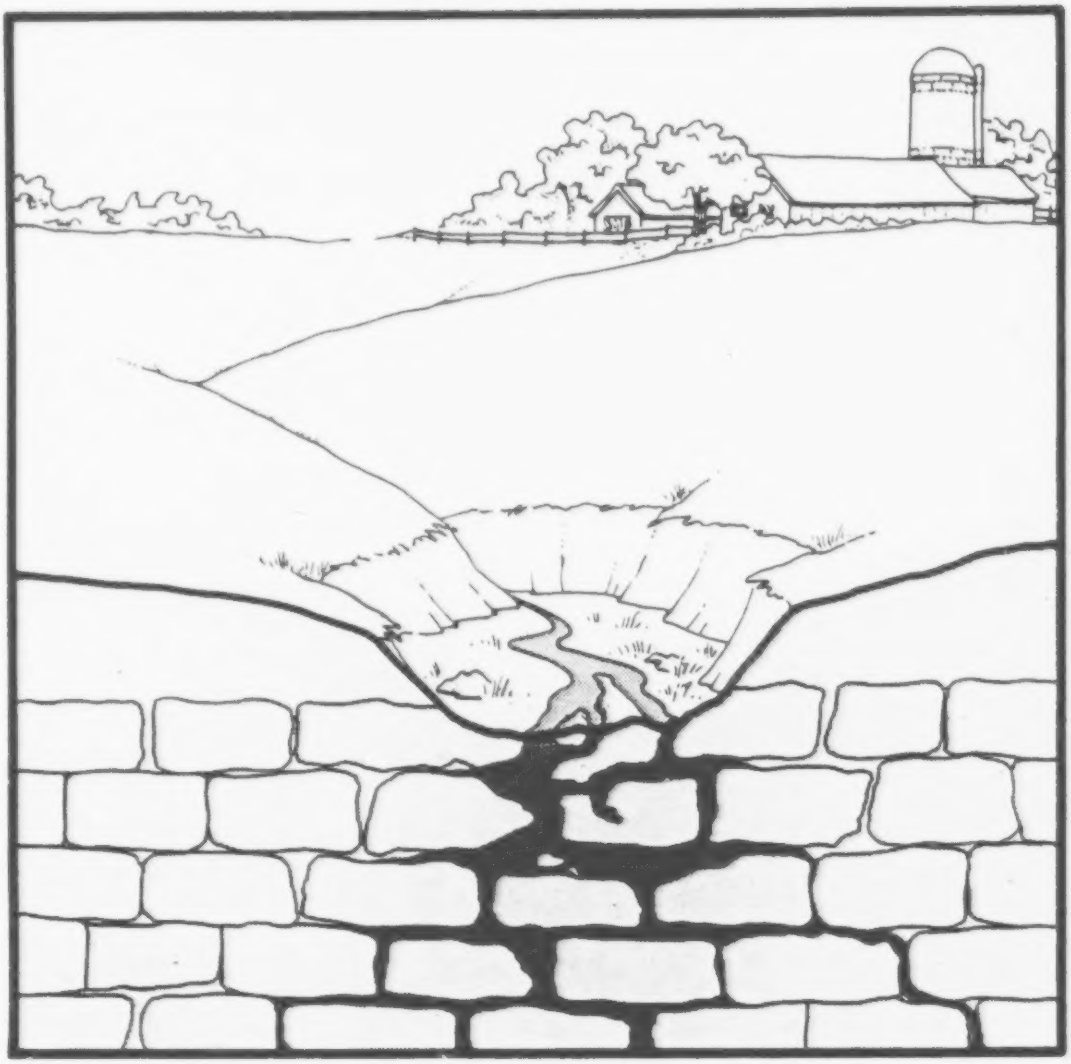
Agricultural Drainage Wells

Starting in the late 1880's, agricultural drainage wells were dug to convert wetlands to agricultural land. The wells were most frequently constructed in the northcentral section of Iowa. Accessible bedrock formations, below the wetlands, were used to dispose large amounts of drainage water which lead to the use of agricultural drainage wells.

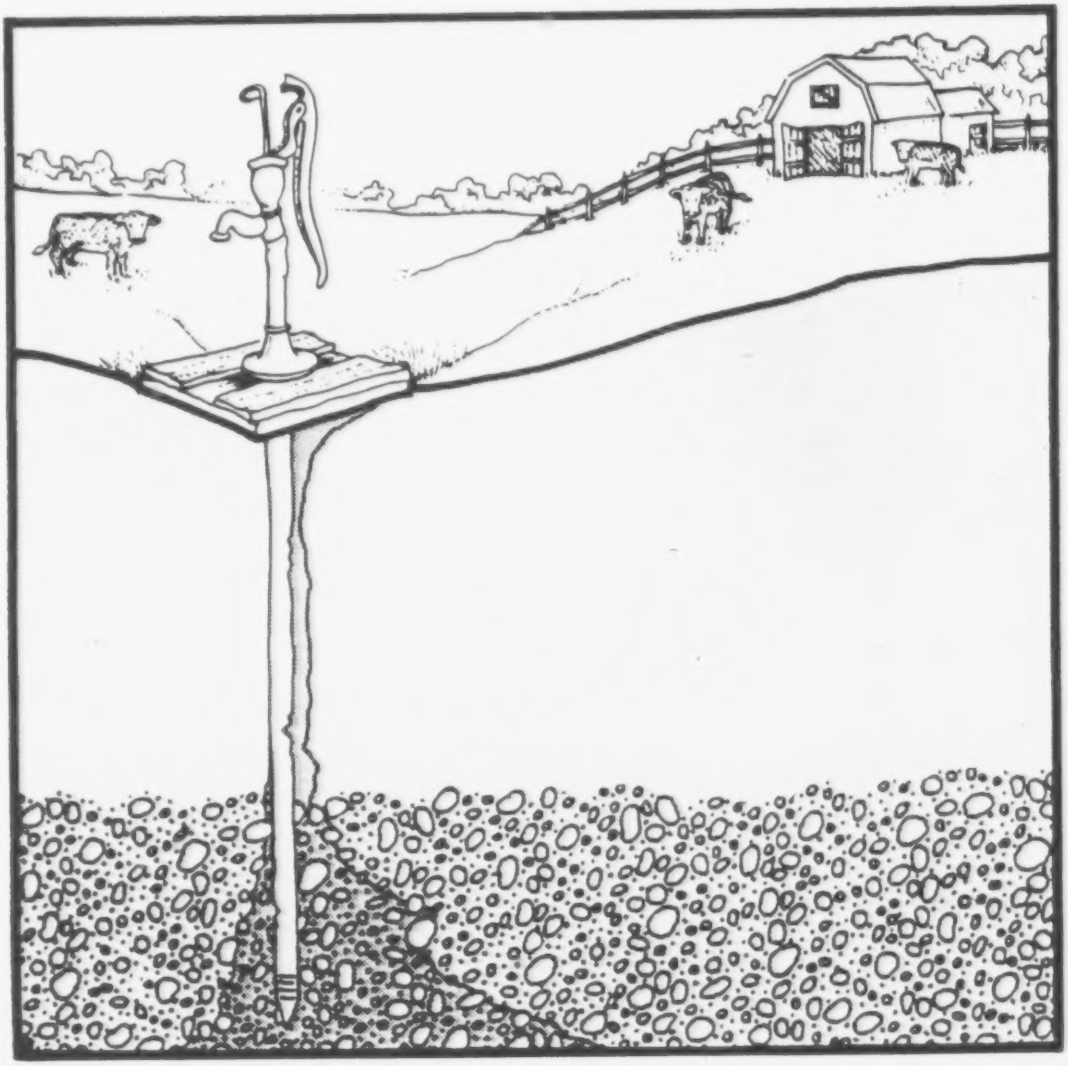
Alternatives to drainage wells might include extending outlets (tile mains or pumps) to available open ditches or converting fields to wetlands. Removal of excess water from fields could be expensive in some cases, but without adequate field drainage, crop yield will suffer. The land topography, farming systems used, groundwater pollution potential and other factors must be considered in making decisions about management of excess surface water.

By 1991, all agricultural drainage well owners must submit a plan to the Iowa Department of Agriculture and Land Stewardship that shows how contamination will be eliminated from their agricultural drainage well or wells.

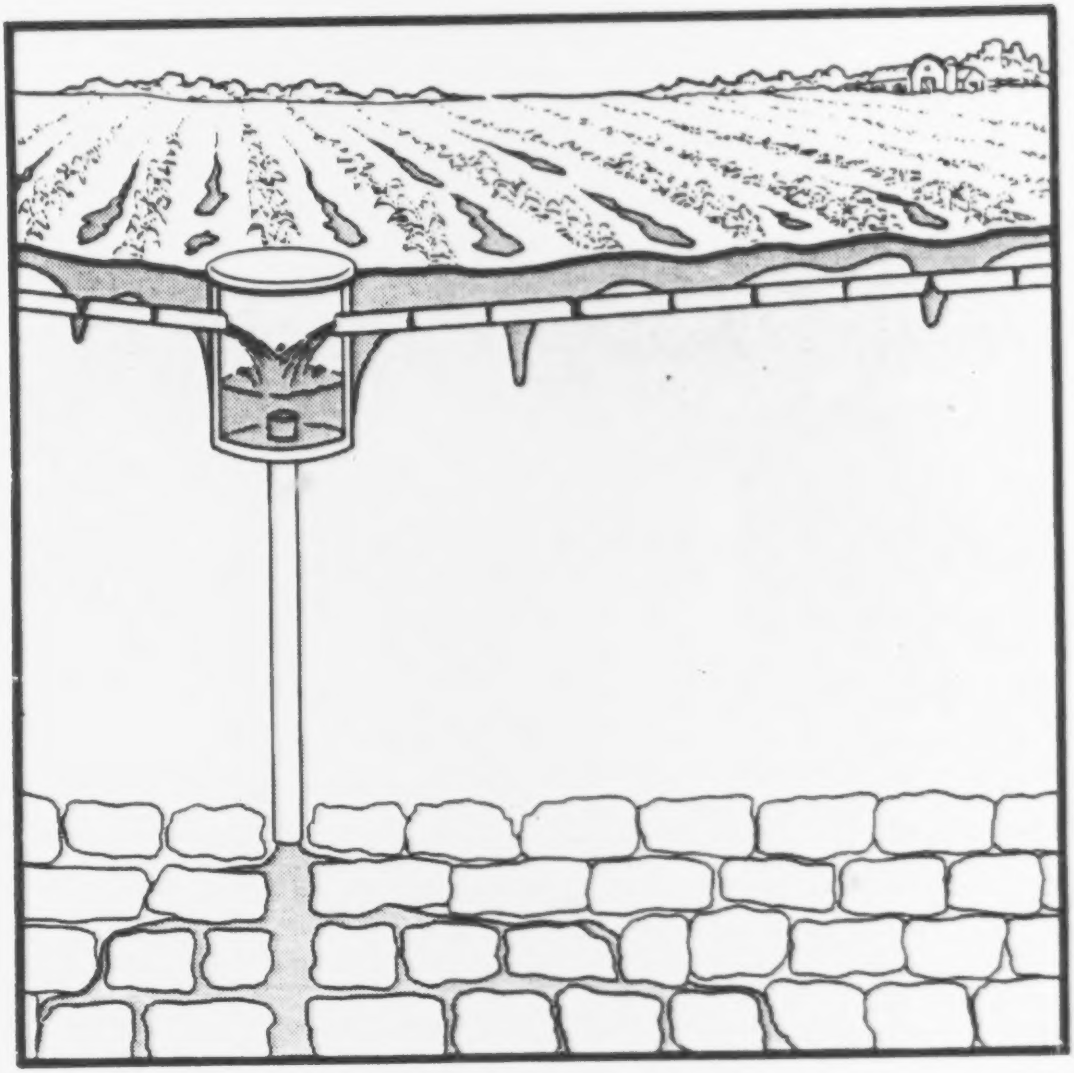
A PROFILE OF SINKHOLES



PROFILE OF ABANDONED WELLS



PROFILE OF AG DRAINAGE WELLS



EXPERIMENT: SIMULTATING GROUNDWATER CONTAMINATION:[1]

PURPOSE: To demonstrate a groundwater system's capacity to flush contaminants entirely from its system.

EQUIPMENT NEEDED:

1 - Bread pan

Sand

1 - Empty soup can with both lids removed

1 - tablespoon

Food coloring

Water

1 - Sprinkler can

1 - Syringe

PROCEDURES

Pour the sand into the bread pan and carefully level the sand. Dye the water in the sprinkler can with food coloring. Thoroughly sprinkle the sand with the dyed water until saturated. Insert the soup can (be careful of sharp edges on the can) into the sand until the can reaches the bottom of the pan. Using the spoon, scoop out the sand located inside the soup can to expose the water table. Extract water by sucking water up inside the syringe. Empty the water in the syringe in a sink. Repeat this procedure until the simulated aquifer is dry. Sprinkle clean water over the sand again to saturate the simulated aquifer. Students should note more "tainted" water in the bottom of their well. Repeat the procedure using "clean" water. Colored water will still be evident in the simulated well.

[1] Credit: Dr. Tom Glanville, Iowa State University, Cooperative Extension Service.

LOCAL SAFETY CHECK

Organize a local safety check to identify direct paths of groundwater contamination. Be sure you have the permission of the landowner/operator prior to this activity. (This activity could be a major thrust of a FFA Safety Program.) Divide the community area up among FFA members and notify the newspaper, local farmers, and officials prior to conducting the check. Develop a checklist for students to use when conducting the check. Report the chapter's findings to the community through the media. Discuss ways to correct some of the direct paths of groundwater contamination.

SUGGESTIONS: Upon completing this activity, ask students to determine the goals and objectives of the survey. Ask each student to submit two questions, that they feel should be included in the survey. After collecting the questions, conduct an open discussion to evaluate the questions as they relate to the goals and objectives established. Form a subcommittee of the safety committee to be responsible for the final draft of the survey and the recruitment of chapter members to help conduct the survey. Be sure to include all of the procedures used in written reports. Involve your administrators, advisory committee, and school board members whenever and wherever possible.

A SAMPLE CHECKLIST FOR CONDUCTING A LOCAL SAFETY CHECK:

1. Identify the area to be surveyed.

2. Using a soil survey, aerial photos and county atlas, plot locations of abandoned wells, agricultural drainage wells, sinkholes and wells that are being used for drinking water.

3. Estimate the distance from each of the direct route entry sites to the nearest wells that are being used for drinking water.

4. Determine from farmers the depth of their wells and if they have had their drinking water treated.

5. Plot locations of known wells that show traces of contamination and determine the distance from direct routes.

6. Do you find any correlation between location of sites, well depths and contamination or potential contamination of groundwater?

KNOWLEDGE ANALYZER

1. True False An old manually operated well pump is always located directly above an abandoned well.

2. True False Sinkholes are usually found near cave systems.

3. True False An abandoned well casing is a safety hazard.

4. True False Most agricultural drainage wells are located in southcentral Iowa.

5. True False Land topography influences the kind and amount of pollutants that enter our groundwater system.

6. True False Groundwater becomes free of contaminants shortly after the pollution has been stopped.

7. True False Sinkholes are primarily located in northcentral Iowa.

8. True False Agricultural drainage wells are placed where bedrock is far from the land surface.

9. True False Groundwater can be contaminated a long distance away from the entry source.

10. True False Sinkholes have long been used for dump sites.

Locating Direct Connections

LESSON 2: Identifying Methods to Restrict Entry of Groundwater Contaminants

GOAL:

Once the entry site of the groundwater contaminant has been identified, ways should be found to prevent contamination through this site. It is critical that individuals and agencies responsible be notified and that correct methods be used to restrict the entry of groundwater contaminants.

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

1. Analyze the advantages and disadvantages of methods used to restrict groundwater contamination through sinkholes, abandoned wells and agricultural drainage wells.

2. Identify the state agency and general laws that regulate groundwater quality related to sinkholes, abandoned wells, and agricultural drainage wells.

MATERIALS:

Overhead Projector, Groundwater Flow Model or video, Groundwater Flow Manual, Groundwater Act: How Does It Affect You?

VISUAL MASTERS:

VM-METHODS-1	How the Groundwater Act Affects Direct Paths of Contamination

ACTIVITIES:

ACT-METHODS-1	Direct Paths of Groundwater Contamination
ACT-METHODS-2 & Key	- Reducing Direct Paths of Groundwater Contamination
ACT-METHODS-3	Knowledge Analyzer

INFORMATION:

INFO-METHODS-1	Plugging Abandoned Wells

INTEREST APPROACH:

In Lesson 1 we identified sinkholes, abandoned wells and agricultural drainage wells as direct paths to groundwater contamination. Ask: How can we reduce the number of these groundwater contamination entry sites? Using the groundwater flow model or video, ask students for possible methods of reducing contamination through abandoned wells, agricultural drainage wells, and sinkholes. Use the groundwater flow model to demonstrate direct paths of groundwater contamination, and to generate a class discussion on methods to reduce potential contamination through these paths. Use ACT-METHODS-1 and the Manual for Use of the Groundwater Flow Model to guide the demonstration and discussion. Point out that Iowa regulations require that contamination through these routes be reduced.

TEACHING PROCEDURE:

1. Divide participants into two groups to become part of a state task force entitled "The State Well and Sinkhole Study Task Force." Use ACT-METHODS-2, to guide the activity and INFO-METHOD-1 as a reference. Use KEY-ACT-

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Prepared by Martin Frick, Department of Agricultural Education, Iowa State University, Ames, Iowa, June, 1989.

METHODS-2 to summarize the role playing activity.

2. Use VM-METHODS-1 and "The Groundwater Act -- How it Affects You?" to identify the regulation pertaining to agricultural drainage wells, sinkholes and abandoned wells. Also identify state agencies regulating this portion of the Iowa law.

3. Assess participants' knowledge of the material covered by administering "Knowledge Analyzer" using ACT-METHODS-3. Answers are 1=F, 2=F, 3=F, 4=T, 5=T, 6=T, 7=F, 8=T, and 9=T.

SUMMARY:

Emphasize that any hole in the ground may carry pollutants to the groundwater system. There are three direct paths of contamination in Iowa that are of special concern: agricultural drainage wells, abandoned wells, and sinkholes. Agricultural drainage wells take sediment, nitrogen, and pesticides into the groundwater which is a primary source of drinking water in Iowa. Abandoned wells also carry surface runoff, including human and animal waste, fertilizers, and pesticides directly into deeper layers of groundwater. Sinkholes have been used as dumps, and are entry sites for groundwater contaminants. The number of entry sites can be reduced. First, entry sites need to be identified. Second, specific procedures should be followed to plug entry sites, or in the case of agricultural drainage wells and sinkholes, restrict contaminants that flow into the entry site.

DIRECT PATHS OF GROUNDWATER CONTAMINATION - - A GROUNDWATER FLOW MODEL DEMONSTRATION

Use the Groundwater Flow Model Video and Manual to answer the following questions:

1. (Demonstration No. 17) Can a well draw contaminants from "downstream"?

2. (Demonstration No. 16 and the demonstrations on page 5) Where do contaminants normally enter the groundwater?

3. (Demonstration No. 25) How do wells, abandoned wells, sinkholes and agricultural drainage wells affect groundwater quality?

REDUCING DIRECT PATHS OF GROUNDWATER CONTAMINATION

Situation

Your group consists of a state representative, a farmer, a Sierra Cub member, a chemical company representative, and other interested citizens of a state task force entitled, "The State Well and Sinkhole Study Committee." You realize that contaminants are reaching the groundwater through abandoned wells, agricultural drainage wells, and sinkholes. Your goal is to find a method to reduce further groundwater contamination through these direct paths.

You have been appointed to this study committee to recommend solutions to this problem.

Select a chair and a recorder for your group. Find solutions to the following questions.

1. What would be the most practical method to prevent contamination through agricultural drainage wells? What kind of incentives would farmers need to convert areas around drainage wells into wetland areas for water filtering and wildlife habitat?

2. What would be the most practical method to prevent contamination through abandoned wells?

3. What would be the most practical method to prevent contamination through sinkholes?

4. Should all agricultural drainage wells, abandoned wells and sinkholes be plugged? Be prepared to defend your answer!

5. Who should pay for the plugging of direct paths of groundwater contamination? If more than one source of financing is recommended, what percent should each pay?

REDUCING DIRECT PATHS OF GROUNDWATER CONTAMINATION

1. What would be the most practical method to prevent contamination through agricultural drainage wells?

   Use INFO-PATHS-1 from the first lesson as background information. Some alternatives to consider are: use a good nitrogen and pesticide management program, eliminate agricultural drainage wells and convert the area to wetland, remove surface inlets, allow the soil to filter out some potential contaminants before water reaches the field tile lines.

2. What would be the most practical method to prevent contamination through abandoned wells?

   Plugging. See INFO-METHODS-1

   Standby Wells

   Standby wells must be disinfected when taken out of use for a long period of time and must be disinfected and checked for bacterial safety when placed back in service after being out of use for a prolonged period. The well casing must be provided with an airtight cover when the well is not in use.

3. What would be the most practical method to prevent contamination through sinkholes?

   Practices to consider in watersheds above sinkholes are: seed to grass or plant to trees; use filter strips, crop rotation, conservation tillage, contour strip cropping; use good fertilizer and pesticide management program; and eliminate use as a dump site.

4. Should all agricultural drainage wells, abandoned wells and sinkholes be plugged? Be prepared to defend your answer.

   See "The Groundwater Act, How Does It Affect You?" (in the appendix).

5. Who should pay for the plugging of direct paths of contamination? If more than one source of financing is recommended, what percent should each pay?

   Use the consensus of the group as an answer since there is no definite right answer.

Plugging Abandoned Wells

Good health is important to us all. Keeping our food and water pure is one way to help insure good health.

Some food—an orange, for example—has natural barriers against contamination. As long as the rind covers the orange, dirt and bacteria are kept out. But once the rind is damaged or removed, the likelihood of contamination increases.

Similarly, the water we pump from our wells is protected by a "rind" of topsoil, clay, and other natural materials. These prevent silt, bacteria, virus, and even some kinds of chemicals from getting into our water supplies.

Because groundwater is our best source of high quality water, we rely heavily on it. About 80 percent of the water used in Iowa for irrigation, public water supplies, livestock production and in rural homes is pumped from wells.

To tap underground water sources, we deliberately drill holes—called wells—through the protective soil and rock that blankets them. This temporarily exposes groundwater to runoff and contaminants from the surface. Using modern construction methods, well drillers restore groundwater protection at the well site by carefully sealing and capping the well. As a result, water can be pumped from the ground without allowing bacteria, silt and other contaminants to enter.

We know, however, that there are thousands of old wells in Iowa that are not properly constructed or maintained. Geologists, sanitarians and well drillers throughout the state frequently report contamination of properly constructed wells by pollutants that enter the groundwater through abandoned wells. Furthermore, the covers of old wells are often badly deteriorated or missing, making them a serious safety hazard to unsuspecting children or animals.

Everyone's Problem . . . and Duty

Abandoned wells are found everywhere—on farms, at industrial sites and in urban areas. A recent survey by county assessors indicates there are at least 35,000 to 40,000 abandoned wells in Iowa. The large number of abandoned farmsteads across the state suggests there may be many more. In 1900 there were nearly 225,000 inhabited farmsteads in Iowa, and most had at least one well. Today, only half of those farmsteads are still occupied.

Recognizing the threat to personal safety and groundwater quality posed by large numbers of abandoned wells, the Iowa Legislature passed a law in 1987 calling for all abandoned wells to be plugged. The Iowa Department of Natural Resources and the Department of Agriculture and Land Stewardship are coordinating this effort.

Get the Job Done Right!

Effective well plugging restores the groundwater protection originally afforded by layers of soil and rock present before the well was drilled. Filling a well also eliminates the possibility of injury, death or property damage due to falls or sudden collapse of an old well beneath the weight of equipment or new structures. **To achieve these important benefits, the right plugging materials and procedures must be used.**

Plugging Strategy

Iowa's groundwater comes from layers of sand and gravel, fractured limestone, and sandstone. These are sandwiched between protective layers of clay, shale, or unfractured limestone which yield little useful water but are natural barriers to migration of contaminants into the water-producing rock. The general strategy for effective well

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Written by Tom Glanville, Extension agricultural engineer, Iowa State University, Ames, Iowa 50011.

IOWA STATE UNIVERSITY EXTENSION

Pm 1328 | July 1988

plugging is to place a plug of sealing material at the top of each water-producing layer. This restores the protection originally provided by overlying layers that were penetrated during well construction.

Materials

Careful selection and use of materials is essential to effective well plugging. Two kinds of materials are used in well plugging. Each plays a special role.

Sealing materials are used to prevent water from migrating into or between water-producing zones. These materials form an impermeable plug that will not shrink or crack. Typical sealing materials include:

- Neat cement—six gallons of water to each 94-pound bag of cement;
- Cement grout—cement, sand and water;
- Concrete—cement, sand, gravel and water;
- Powdered or granular forms of bentonite clay.

Fill materials are low-cost granular materials used to plug portions of a well where sealing is not essential. Clean sand, gravel, crushed stone or agricultural lime are recommended fill materials. These are strong, resistant to settling (if properly installed), and readily available throughout most of Iowa. Never use waste materials or other potential contaminants as fill material for well plugging.

Fill is not necessary for every plugging job. It is used mainly in large wells to reduce costs. This is done by placing the relatively expensive sealing materials at strategic locations and packing the remainder of the well with lower priced fill materials. **For smaller wells, however, it is often less time-consuming and more cost effective to use sealing materials throughout the full depth of the well.**

General Recommendations

Several features are common to abandonment of any well:

- All pumping equipment and pipes should be removed from the well;
- Well casing and well pits should be removed to a depth of four feet to eliminate interference with future use of the site;
- Neat cement or bentonite clay products are the only sealing materials that are recommended for use below water. Sand and gravel used in concrete or cement grout tend to separate out and weaken these sealing materials when they are placed below water;
- Soil should be mounded over the plugged well to prevent ponding of surface water above the site.

In wells less than 18 inches in diameter, sealing materials should be pumped into the well through a tremie pipe—a tube temporarily inserted to the depth where plugging materials are to be positioned. **Simply dumping sealing materials into the top of small diameter wells is not effective as they may bridge across the narrow casing or become diluted and weakened by water inside the well.** To help insure effective plugging, small diameter wells should be filled by a registered well driller who has the equipment to pump plugging materials into the abandoned well.

Wells greater than 18 inches in diameter and less than 100 feet deep can be filled from the top since the casing is large enough to prevent bridging. Granular sealers, such as pelletized bentonite clay, are best suited for filling from the top. They settle rapidly through standing water and swell when wet to form an effective plug.

Specific Plugging Sequence

Recommended placement of fill and sealing materials is described in the text accompanying the drawings in this publication for several kinds of wells commonly used in Iowa. To block migration of contaminants into or between water-bearing zones, sealing materials must be placed at the top of each water-bearing zone tapped by the well. Unfortunately, exact depths to water-producing zones are unknown for many old wells. In these cases the surest method of preventing groundwater contamination is to completely fill the well with sealing material. If the well is so large or so deep as to make the cost of this prohibitive, fill and sealing materials should be placed in layers in the well in accordance with the best estimates of drillers and geologists familiar with the geology of the area.

Bored or Hand-Dug Wells

These kinds of wells are common in southern Iowa. They often are 36 inches in diameter or larger and require large amounts of fill material. As shown in Figure 1, granular fill material is

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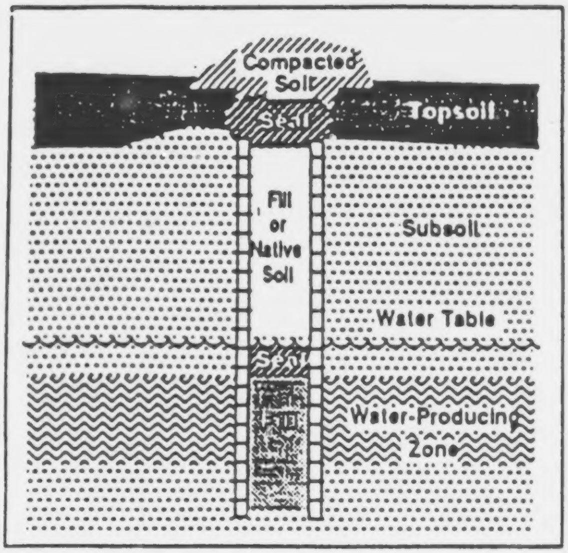
Compacted Soil
Seal
Topsoil
Fill or Native Soil
Subsoil
Water Table
Seal
Fill
Water-Producing Zone

Figure 1. Recommended plugging sequence for bored wells.

recommended below water level. A foot or more of sealing material should be placed at water level and a one-foot thick cement cap poured at the top of the remaining casing. Since a large volume of plugging material is needed, subsoil native to the area may be used as fill between the two plugs of sealing material. If soil rather than granular fill material is used, this material should be compacted to avoid excessive settling in the future.

Sand and Gravel Wells

These wells are generally cased with four- to six-inch diameter steel pipe. They often tap relatively shallow (less than 100 feet deep) sand and gravel deposits in river valleys or glacial deposits in the north central part of the state. As shown in Figure 2, fill material is used adjacent to the water-producing sand and gravel and the remainder of the well is filled with sealing material.

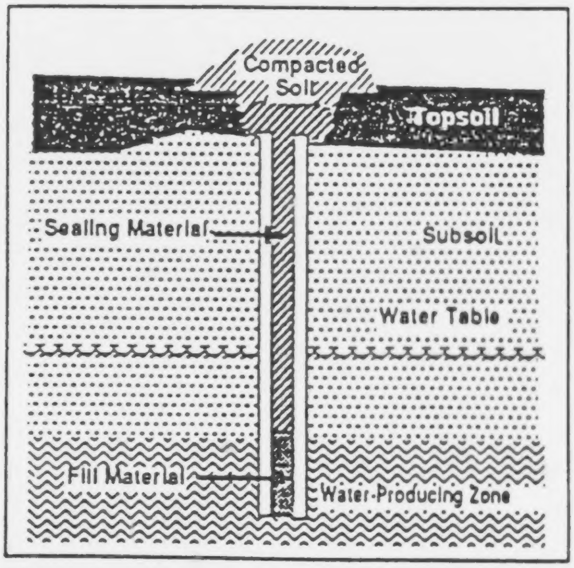
Compacted Soil
Topsoil
Sealing Material
Subsoil
Water Table
Fill Material
Water-Producing Zone

Figure 2. Recommended plugging sequence for sand and gravel wells.

Drilled Wells in Bedrock

Bedrock wells are found throughout Iowa but are most common in northeastern and north central areas of the state. Four- to six-inch diameter steel casing often extends only a short distance into the water-producing bedrock. An open hole in the rock below the casing allows water to enter the well.

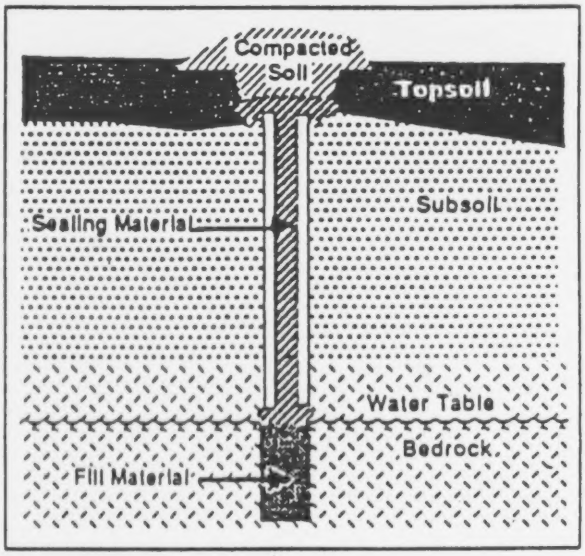
Compacted Soil
Topsoil
Subsoil
Sealing Material
Water Table
Bedrock
Fill Material

Figure 3. Recommended filling sequence for wells tapping a single bedrock layer.

Fill material is placed in the bottom of the open hole as shown in Figure 3. Sealing material should begin about 10 feet below the bottom of the casing and extend to the top of the well. Sealant placed below the bottom of the casing fills large fractures that are common near the top of bedrock layers. As mentioned earlier, the only sealing materials recommended for use below the water line are neat cement or bentonite clay products. Cement grout or concrete may be used above the water table if desired.

In some wells two or more water-producing bedrock layers are tapped. In these cases, sealing plugs should be placed at the top of each water-producing layer, as shown in Figure 4. Fill materials can be used between these plugs to reduce the amount of sealing material needed.

Sandpoint Wells

When possible, the casing pipe should be pulled and the hole allowed to collapse. If the casing cannot be extracted, cut it off four feet below ground, fill the remaining casing with neat cement or bentonite, and backfill with compacted soil.

For Further Information

There is no substitute for a safe dependable water supply. By plugging abandoned wells, you help to protect water quality in the active wells you rely on.

For further information on well plugging, contact the Iowa Department of Natural Resources, your local board of health or county sanitarian, or a registered well drilling and pump installation contractor.

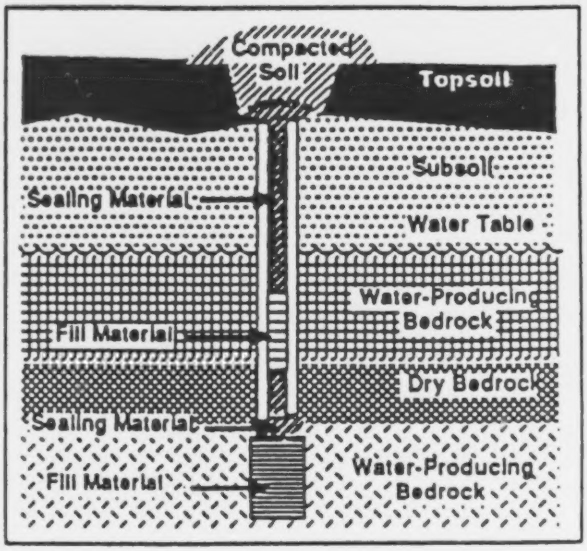

Figure 4. Recommended filling sequence for wells tapping more than one bedrock layer.

These well plugging recommendations were developed by a committee of well contractors and environmental officials whose members gave generously of their time and expertise. Committee members were Donivan Gordon (chair), Roger Bruner, Keith Bridson and Wayne Reed of the Iowa Department of Natural Resources; Ken Choquette of the Iowa Department of Public Health; and members of the Iowa Water Well Association, Jim Schumacher, president, Jack Johnson and Jeff Joslyn.

Information in this fact sheet summarizes many but not all provisions of proposed well plugging rules released for public comment by the Iowa Environmental Protection Commission in March 1988. For a complete copy of the proposed rules and information on the schedule for their final revision and adoption, contact the Iowa Department of Natural Resources (phone (515) 281-6853). Members of the water well industry and others who desire a more thorough discussion of well plugging considerations may obtain **"Guidelines for Plugging Abandoned Water Wells,"** *Technical Information Series 15, from the Geological Survey Bureau of the Iowa Department of Natural Resources (phone (319) 335-1575).*

Cooperative Extension Service, Iowa State University of Science and Technology, and the United States Department of Agriculture cooperating. Ronald C. Powers, interim director, Ames, Iowa. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914.

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HOW THE GROUNDWATER ACT AFFECTS DIRECT PATHS OF CONTAMINATION

State Goal: Eliminate Contamination By 1995

1. All Ag Drainage Wells Registered with DNR by Jan. 1, 1989

2. All Ag Drainage Well Owners -- Submit plan to Department of Agriculture By 1991

3. Permit From DNR Required For New Well Construction After July 1, 1987

4. A Schedule For Closing Abandoned Wells -- To Be Established

5. A Financial Assistance Program For Closing Abandoned Wells -- To Be Established

6. After July 1, 1987, Upon Sale of Property Landowners Must Disclose Any Waste Disposal Site, Underground Storage Tank or Existing Well On The Property

ACT-METHODS-3

KNOWLEDGE ANALYZER

1. True False The state government will pay 100% of the costs of plugging an abandoned well.

2. True False The plugging of wells involves pouring some concrete over the top of the well.

3. True False Materials used to seal a well include sand, pea gravel, or crushed stone.

4. True False Pasture, filter strips and tree planting could minimize groundwater pollution in sinkhole areas.

5. True False Standby wells must be disinfected when taken out of use for a long time.

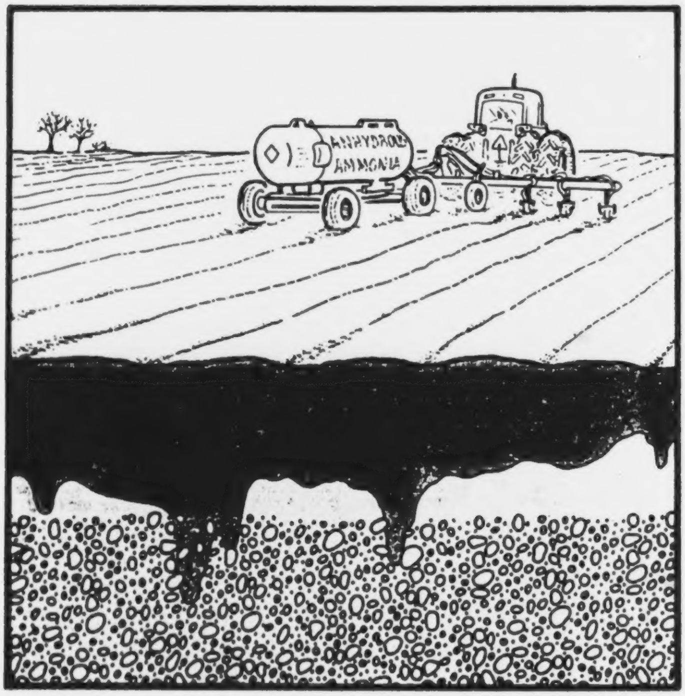
6. True False Agricultural drainage wells must be registered with the Iowa Department of Natural Resources.

7. True False Groundwater contamination through sinkholes can be eliminated.

8. True False Fill materials are used to occupy space where sealing materials are not needed when plugging abandoned wells.

9. True False Abandoned well owners must inform DNR, within thirty days of completion of plugging, that their well has been properly plugged.

MANAGING NITROGEN FERTILIZERS



EDUCATIONAL CONCEPTS

- How nitrates get into water
- Health effects
- Best farm management practices
- Energy conservation

Managing Nitrogen Fertilizers

LESSON: Understanding the Relationships between groundwater, agricultural use of nitrogen fertilizers, and health problems

GOAL: Since you will be our future agriculturists, it is important to understand the severity of the nitrate problem, it's health effects, and how contamination of groundwater by nitrogen fertilizer can be reduced.

OBJECTIVES:

After completion of this lesson the participant should be able to:

1. Correlate the agricultural use of nitrogen fertilizers to groundwater based health and environmental concerns.
2. Track the routes and different forms of nitrogen to surface and groundwater.
3. Plan soil management systems to limit nitrogen loss, conserve energy, and improve groundwater quality.
4. Analyze the Groundwater Protection Act and its effect on the use of agricultural nitrogen.

MATERIALS:

Nitrates and Groundwater: A Public Health Concern; Water Quality Field Guide; Journal of Freshwater Foundation: A Guide for Safe Profitable Fertilizer and Pesticide Use; Nitrate Test Kit from Hach Chemical, 100 Dayton Road, Ames, Iowa, 50010, Cost approximately $12 and can perform 50 samples (not included in materials); List of certified water sampling labs; Overhead Projector; Soil Samples; Pots Groundwater Flow Model or Video; Groundwater Flow Model Manual; Area Soil Survey Reports (Obtained from local SCS or extension office).

VISUAL MASTERS:

VM-NIT-1	Nitrogen levels and health concerns
VM-NIT-2 a , b	Nitrogen use 1940-1980
VM-NIT-3	Steps to increase nitrogen efficiency

ACTIVITIES:

ACT-NIT-1	Nitrogen health concerns
ACT-NIT-2 and KEY	Nitrogen cycle
ACT-NIT-3 and KEY	Soil influences on nitrogen movement in the environment
ACT-NIT-4 and KEY	Steps to increase nitrogen efficiency
ACT-NIT-5	Summarization exercise
ACT-NIT-6 and KEY	Nitrogen application
ACT-NIT-7 a,b,c	Discussion and summarization

INFORMATION:

INFO-NIT-1	Nitrate Problem
INFO-NIT-2	Characteristics and management of nitrogen
INFO-NIT-3	Nitrogen health concern exercise
INFO-NIT-4	Management terms and practices
INFO-NIT-5	7 Management Steps

Prepared by Randy Bowman, Department of Agricultural Education, Iowa State University, Ames, Iowa, June 1989.

INTEREST APPROACH:

This should be prepared at least three weeks before the beginning of the lesson.

Divide the participants into groups to plan the following activity. Let each group report their recommendations. After hearing all group reports make plans for this activity.

1. Assign participants to collect water samples from rural wells, runoff, urban water system and pond. (See Appendix for location of water testing laboratories.)
2. Have the participants mail the samples to certified water testing labs for nitrate analysis.
3. When the results come back, providing some show excessive levels, explain the possible effects that could be caused by the contamination. (You may want to have some dummy samples to insure that some of the samples will come back with some type of excessive levels.)

An alternative interest approach would be to use pots of soil in which varying amounts of nitrate fertilizer (potassium nitrate from a chemical dealer or the chemistry department) were placed and have the participants use the test kits to test the water that flows from each pot when water is added to the surface.

TEACHING PROCEDURES:

1. Use VM-NIT-1 and INFO-NIT-1 to introduce the health effects to humans as well as livestock.
2. Use VM-NIT-2 (a and b overlay) and INFO-NIT-2 in a discussion of the relationship between increased fertilizer usage and increased nitrate contamination.
3. Use ACT-NIT-1, INFO-NIT-1, INFO-NIT-3, and the pamphlet: Nitrates in Groundwater, A Public Health Concern, in an exercise to weigh health issues.
4. USE ACT-NIT-2 and KEY and INFO-NIT-4 to explain nitrogen transformation, movement, and the nitrogen cycle.
5. Use the soil survey report from your area to discuss soil type, topography and other soil factors that would contribute to nitrate leaching into groundwater reserves. USE ACT-NIT-3 and KEY.
6. Discuss management systems. Correlate the use of nitrogen fertilizers, tillage systems, energy conservation and soil type. USE ACT-NIT-4 and KEY, INFO-NIT-5 and VM-NIT-3. (References - Pandora's Box; A Guide for Safe, Profitable Fertilizer and Pesticide Use; the article on pages 14-17 in the Journal of Freshwater, SCS Water Quality Guide; and Best Management Practices to control Groundwater Quality in Iowa)
7. Use ACT-NIT-6 and KEY and INFO-NIT-5 to determine nitrogen application rates.
8. Use INFO-NIT-1 to discuss the effects of the Groundwater Protection Act. List key points on the chalkboard. (See the Groundwater Act - How Does It Affect You - in Appendix)

OTHER ACTIVITIES:

1. Use the Groundwater Flow Model or Video to illustrate how nitrates move in the soil. (Groundwater Flow Model Manual - in Appendix.)
2. Have the participants determine the water reserve contamination laws of surrounding agricultural states as well as those in states more urban in nature.

3. On a field trip, the participants could visit a water treatment plant to become familiar with the type of purification needed for groundwater to become potable water.
4. Set up a demonstration in which chemical nitrates have been added in varying degrees to the soil in the pots. Make sure that there is a way to drain the pots and collect the water coming from the pots. Test the leachate for nitrates and you should get different concentrations of nitrates in the leachate.
5. Have the participants investigate the wells in the area such that they could infer the type of pollution that might be occurring in the area.

SUMMARY:

Use ACT-NIT-5 and ACT-NIT-7 to summarize this lesson.

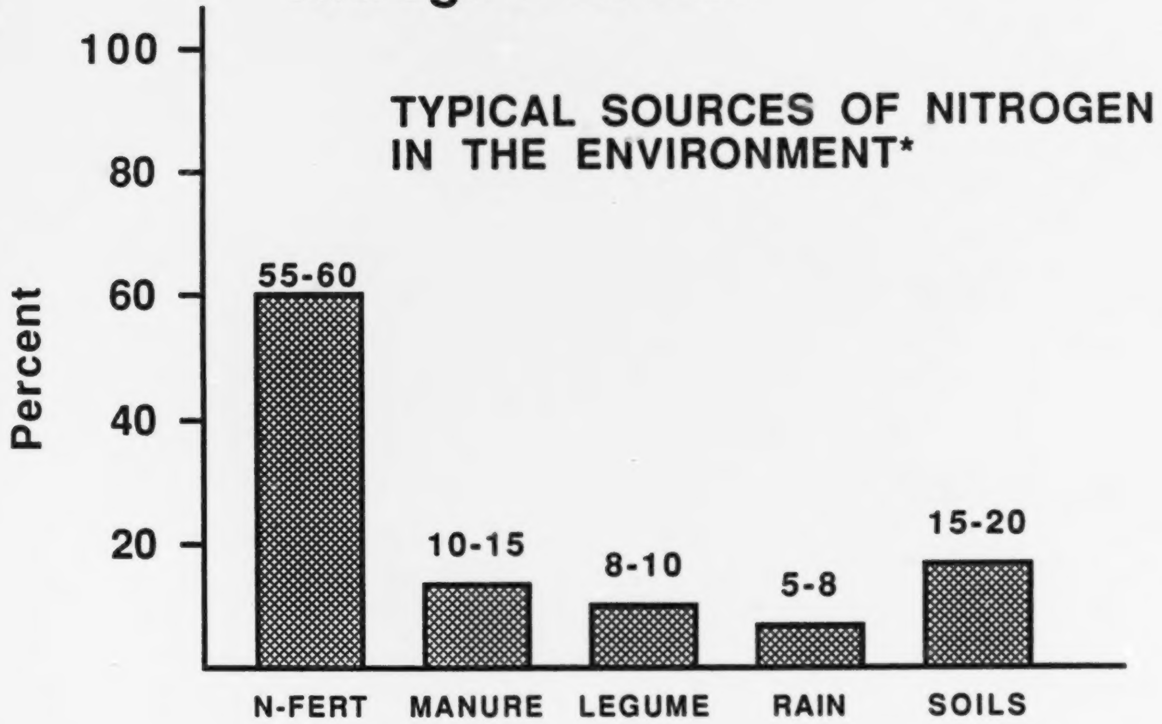
FUTURE DEVELOPMENTS:

Dr. Alfred Blackmer, Iowa State University, has been conducting research on nitrogen applied as fertilizers. Using special labeled nitrogen (N^{14}), his research has shown that a significant amount of nitrogen fertilizer applied with traditional fertilizer application practices was not recovered in the plant or the soil. This led to the modification of a procedure that could accurately measure the amount of nitrogen in young plants rather than in the soil.

The significance of this procedure is that it would allow farmers to apply nitrogen when needed (timing) and in the amount needed (rate) to assure that adequate nitrogen would be available for the plant without excess nitrogen that could contaminate groundwaters. This availability allows for the application of lesser amounts of nitrogen fertilizer.

The procedure, however, is still in the experimental stages and there are some modifications to be made before or if release for public use is determined. A kit that uses the procedure has been field tested and the first results indicated that some changes had to be made. The second field test will be performed in the summer of 1989.

Nitrogen Levels



LEGAL HEALTH LIMITS

45 mg/l as Nitrates (NO_3^-)

10 mg/l as elemental Nitrogen (NO_3^-)

ADVERSE HEALTH AND ENVIRONMENTAL IMPACTS

Human
  Long Term - Chronic Possibilities (such as cancer)
  Short Term - Acute - Methemoglobinemia (Blue Babies)

Livestock - Symptoms observed but not widespread problem

Environment - can cause increased growth of algae in ponds, reducing oxygen for fish

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* Hallberg, G. Nitrates in Groundwater in Iowa. Proceedings from Iowa Fertilizer and Chemical Assoc. Conference. 1986

NITROGEN-HEALTH CONCERNS EXERCISE

A clean safe water supply is one of the cornerstones of good public health.

There is a possible threat to our water supplies in the form of nitrogen fertilizers that are soluble in the soil and will move with the movement of water. Water from wells polluted by nitrates can cause a life-threatening condition in infants known as "blue baby syndrome" (methemoglobinemia). There are also long-term consequences to nitrate pollution in groundwater in the form of possible cancer causing compounds.

Nitrogen is an essential element to living matter. It occurs naturally in the environment in many forms including nitrate. Ammonia is present in waste from humans and animals and occurs in the soil through microbial action and is also applied as a fertilizer. Other microbial actions convert the ammonia to nitrate in the soil. This is important as nitrate is water soluble and can enter groundwaters while the ammonium form is held in the soil and does not leach but can reach groundwater reserves through erosion and indirect entrance to groundwaters.

When more nitrate accumulates than the growing plants can use, any type of precipitation can carry the soluble nitrate form down through the soil and into the groundwater. This is a process called leaching and how fast the process works is dependent on the soil type. Water moves rapidly through sand or gravel or where porous limestone rock underlies shallow soil.

The Environmental Protection Agency and the Public Health Service have recommended a maximum level of nitrate concentration in drinking water. That level is 10 mg per liter of nitrate nitrogen or its equivalent of 45 mg per liter of nitrate.

Nitrate pollution, exceeding the recommended levels, has increased in the recent years and many point to the increased use of nitrogen fertilizer as one of the possible causes.

Recent studies have found increasing problems with nitrates in drinking waters. In the spring of 1984, more than 40 public water supplies in Iowa exceeded the drinking water standard for nitrates. Washington County, Illinois had nitrate concentrations above the standard in 81% of dug wells and 34% of drilled wells.. About 25% of private water supplies in Iowa exceed the current nitrate standard. The nitrate in the groundwater can contribute to infant mortality by blue baby syndrome.

Blue baby syndrome occurs when a baby consumes water polluted with nitrate, and the bacteria in the infants stomach converts the nitrate to nitrite. Relatively low acidity in an infant's stomach creates an ideal environment for the bacteria that convert the relatively safe nitrate into the dangerous nitrite. The nitrite interferes with an important chemical reaction in cells that carry oxygen to the tissues and results in oxygen starvation in the infant. This causes a bluish condition in infants, hence the "blue baby syndrome." Once an infant reaches about six months in age, blue baby syndrome is no longer a problem.

There are basically four reasons why infants are at risk from nitrate pollution of water supplies. These are: 1) Infants less than six months in age have relatively low acidity in their stomach creating an ideal environment for bacterial growth. 2) Infants consumes a large intake of fluids relative to their body weight. 3) Infant blood is more rapidly oxidized by nitrites. 4) The enzymes necessary to convert oxygen non-carriers to oxygen carriers are not completely developed in infants.

Nitrate contaminated well water may be increasingly important in rural areas. The commonalty of the disease is currently not known as blue baby syndrome has not been routinely reported to departments of health although the mortality rate of the disease is about 8 to 10%.

This disease can be prevented by simply testing the drinking water in your household. However, boiling your water which removes many contaminants, actually increases the concentration of nitrates in the water.

Nitrates and nitrites can interact with other compounds that are known to cause cancer. The research, though, is scarce and there has not been a direct link to cancer by nitrate or nitrite compounds.

Because of the scarcity of research on health hazards caused by nitrogen containing compounds, the best course of action is to take reasonable steps that will limit human exposure to the compounds.

Though finding and correcting the source of nitrate contamination is the best course of action, some home filtration systems such as distillation units, ion exchange units, and reverse osmosis units provide effective home treatment for removing nitrates from the water. These processes of removal are expensive and complicated.

The problem of nitrate contamination may be more of a problem with livestock. This is because most of the water ingested comes from sources that have not been tested for nitrate contamination. The feed also comes from sources that may be higher in nitrates. Recent assessments of the incidence of nitrate poisoning in livestock have indicated that nitrate poisoning is not a widespread problem. (Keeney)

The environmental effects of nitrates are less serious than the human and animal effects but can have eutrophic effects on surface reservoirs (Keeney). Eutrophication is the natural or artificial process of nutrient enrichment of a body of water causing increased growth of aquatic plants thus lowering the oxygen content of the water to a point which may become detrimental to the growth and survival of fish.

Practices which will reduce high nitrates in the soil solution as well as those that reduce soil erosion and the and the movement of ammonium nitrogen attached to the soil particles will reduce groundwater pollution to a minimum.

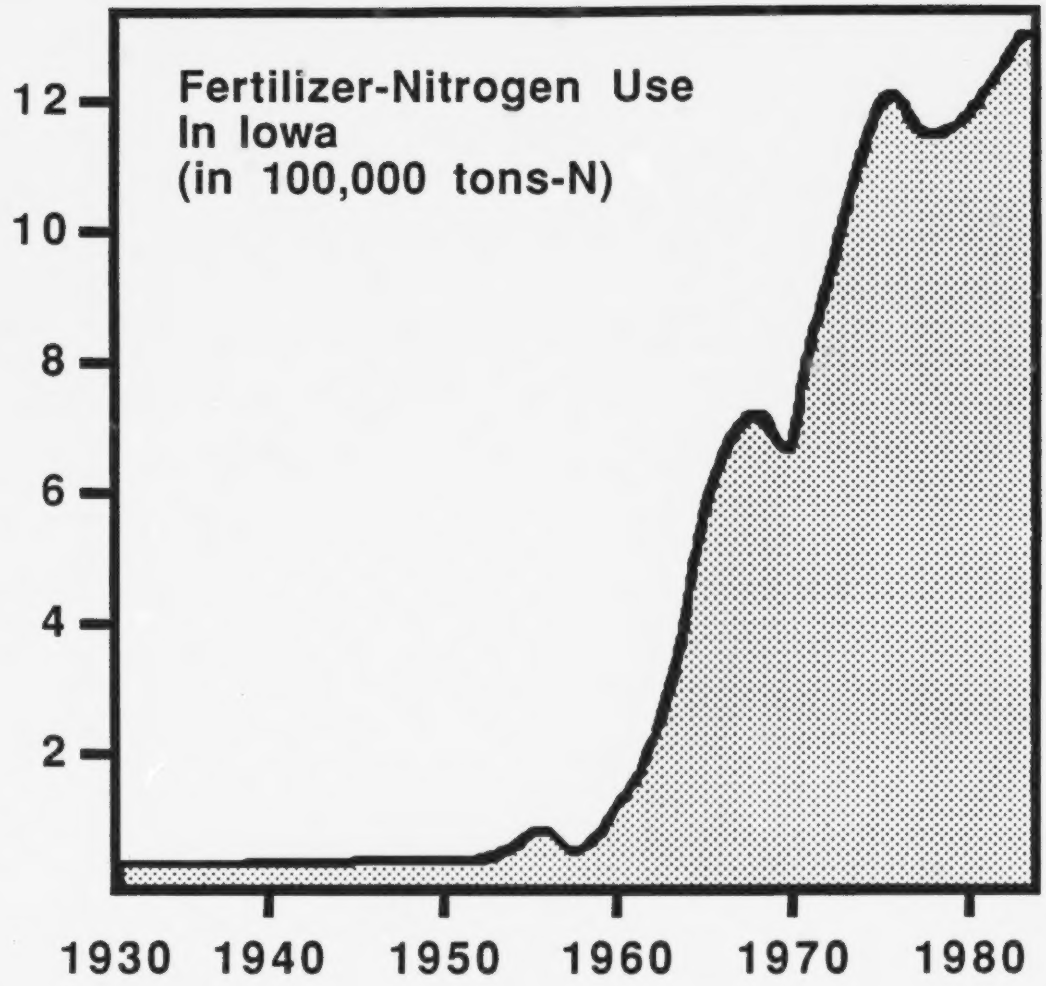
References

Plumb, Deborah and Muriel Morrisette. 1988. Nitrates and Groundwater: A Public Health Concern. 1988. Freshwater Foundation, Navarre, Minnesota.

Keeney, Dennis, Daniel T.C., and B. Shaw. 1980. Nitrate in Wisconsin Groundwater: Sources and Concerns. University of Wisconsin Extension.

Nitrogen Use*

VM-NIT-2a



Fertilizers

Nitrate forms highly soluble and leach, ammonia forms are insoluble and do not leach

Avoid fall applications, nitrification Inhibitors may help

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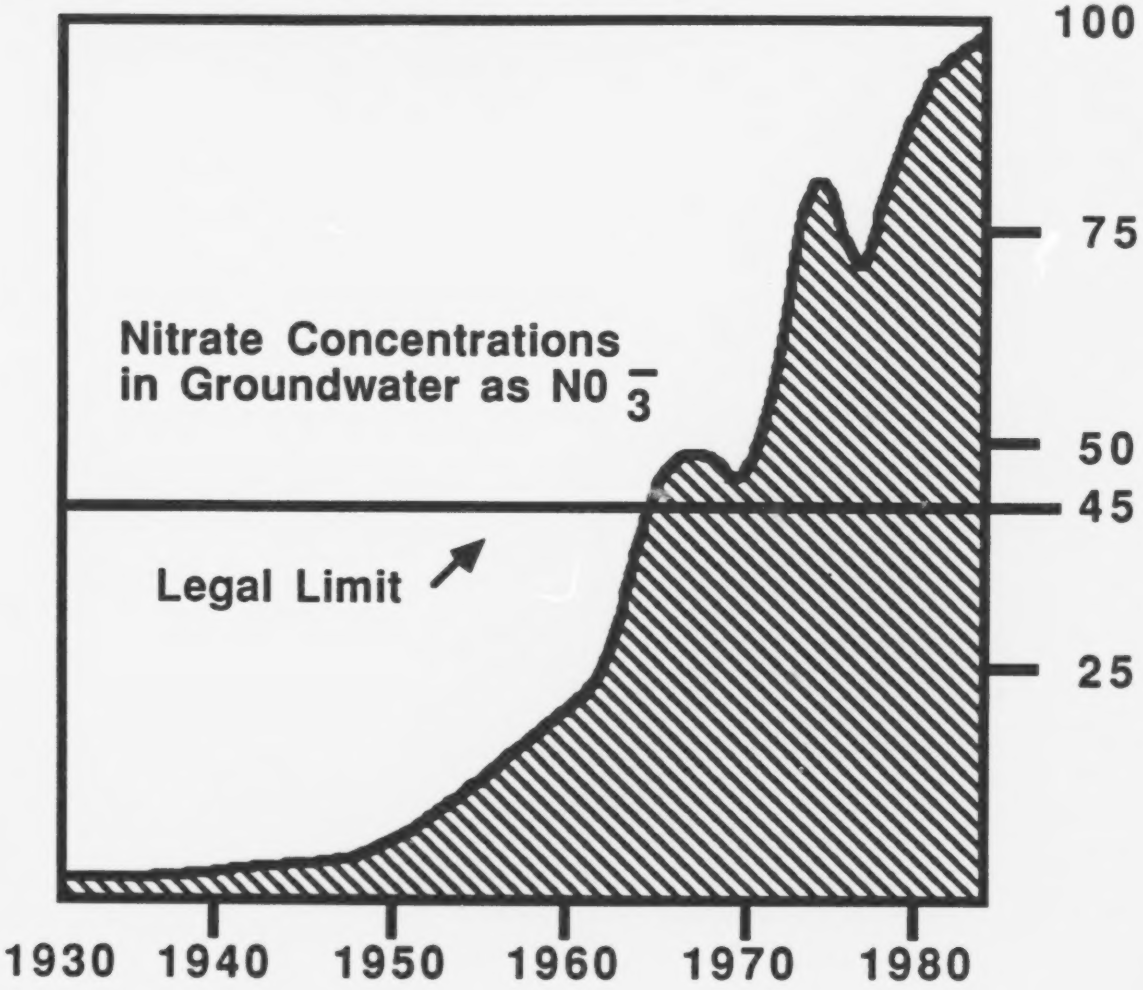
* In: Groundwater Protection Strategy, Hoyer, B.E. et.al. 1987

VM-NIT-2b

Contamination Levels



INFO-NIT-2

CHARACTERISTICS AND MANAGEMENT OF NITROGEN

Groundwater contamination by nitrogen has increased dramatically since the 1960's. This closely correlates with the development of "cheap nitrogen" by which farmers could afford to fertilize heavily. About 1,000,000 tons of nitrogen fertilizers are applied to corn in Iowa each year. Alfalfa and soybeans grown in Iowa fix approximately 650,000 tons of nitrogen annually. Mineralization in agricultural soils in Iowa generates approximately 750,000 tons of nitrogen annually. All of these sources contribute nitrate to the soil system (Best Management Practices to Improve Groundwater Quality in Iowa - Extension Service). As more fertilizer is applied to the soil, crop yields increase, but so does the potential for leaching of soluble nitrate forms and the loss of the ammonium form of nitrogen that is held on eroded soil. Because nitrate is easily leached through the soil, management practices are needed to efficiently utilize nitrogen from all sources. This will minimize the presence of nitrate in the soil when crop plants cannot utilize it and when significant recharge of groundwater occurs.

Nitrogen enters the soil through 1) rainfall, 2) organic matter decomposition, 3) symbiotic 4) non-symbiotic fixation and 5) applied as fertilizers.

Nitrogen occurs in the soil in many forms. The ones that we need to be concerned with are the nitrate form and the ammonium form. The nitrate form is soluble and moves with the water in the soil while the ammonium form is attached to the soil particles and moves when the soil particles move or are eroded. Depending on environmental conditions, the nitrate form or the ammonium form, or both can be present in the soil.

Nitrites are found to be rare in soils, as the bacteria that control the conversion of nitrites to nitrates are not the limiting factor in the conversion. The limiting factor is the bacterial population that converts ammonium to nitrite, the first of two steps in the nitrification process.

Generally, the highest probability that leaching losses of nitrate will occur is when nitrogen fertilizer is applied in the fall and lower when applied in the spring. Combinations of fall soil moisture, spring rainfall expectations and fall soil temperatures at the 4 inch depth should be considered on a risk assessment basis for loss of nitrate before deciding on fall nitrogen application (Killorn, 1985).

Nitrate forms of nitrogen should not be applied to coarse textured soils or under conditions where leaching losses are probable. Ammonium fertilizers must change to nitrate before they can be leached through soil. Anhydrous ammonia has an inhibiting effect on nitrification (Kiehl and Netto, 1974), and this tends to delay the total amount of ammonium nitrified relative to other fertilizer nitrogen sources.

When calculating nitrogen credits for legumes, i. e. alfalfa and soybeans, grown prior to a corn crop, the amount of nitrogen fertilizer can be reduced. (Example, amounts of nitrogen to be subtracted from the recommended nitrogen rate: if grain crop follows forage legume - 140 lbs of nitrogen for first year corn grain from a 50% to a 100% stand of a forage legume or 1 lb of nitrogen/bu of a soybean harvest (Killorn, 1988b)).

The Iowa Groundwater Protection Act did not establish regulations controlling application of nitrogen fertilizer. It encourages the use of good agricultural practices in crop production to conserve, maintain and improve soil productivity and water quality. Funds for research are to be collected from the manufacturing, handling and sales of agricultural products.

Use ACT-NIT-2 and 3 and KEY-ACT-NIT-2 and INFO-NIT-2 to discuss the nitrogen cycle.

ACT-NIT-1

NITROGEN-HEALTH CONCERNS EXERCISE

The following topic areas concern adverse medical effects of groundwater pollution by nitrates.

Answer the following questions from INFO-NIT-1.

1. What are nitrates and how do they get into groundwater?
2. How much nitrate is too much for drinking water?
3. How common is nitrate contamination of drinking water in Iowa?
4. How does nitrate affect human health?
5. What is "blue baby syndrome" (methemoglobinemia)?
6. Why are infants at risk of blue baby syndrome?
7. How common is blue baby syndrome in infants?
8. How can blue baby syndrome be prevented?
9. Can nitrates in drinking water cause cancer?
10. Can nitrates be removed from water?
11. Can you cite examples of the effects of nitrate contamination on livestock and the environment?

What To Do If You Suspect A Nitrate Problem*

If you suspect high nitrate concentrations in your water, you can send samples to a laboratory for analysis. The water should be tested for both bacteria and nitrate because high bacterial counts are often found in water with high nitrate levels.

It is relatively easy to obtain a good water sample, but remember that the amount of nitrate in well water can vary, depending on groundwater movement, infiltration of rainfall, and the source of the nitrate contamination. A single sample and analysis can lead to a false sense of security. Collect water samples in special bottles obtained from the laboratory. To obtain a good sample, let the water run for several minutes to clear out the water in the pipes and pressure tank.

Most laboratories will report the nitrate content of water as parts per million (ppm) of either nitrate or nitrate - nitrogen.

It is difficult to establish precise standards for nitrate concentrations in water that is safe to drink under all conditions. The following table presents conservative guidelines for using water with a known nitrate content.

USE OF WATER WITH KNOWN NITRATE CONTENT

Reported as Elemental Nitrogen	Reported as Nitrate	Interpretation
0 - 10 ppm	0 - 44 ppm	Safe for all animals
10 - 20 ppm	44 - 88 ppm	Safe for livestock inless feed has high nitrate levels
20 - 40 ppm	88 - 176 ppm	Might cause problems for livestock. If feed contains more than 1,000 ppm, total nitrate is likely to exceed safe levels.
40 - 100 ppm	176 - 440 ppm	Risky for livestock. Feed should be low in nitrates, well-balanced, and fortified with Vitamin A.
100 - 200 ppm	440 - 880 ppm	Should not be used. Acute poisoning and some deaths likely in swine. Probably too much intake for ruminants on usual feeds.
Over 200 ppm	Over 880 ppm	Should not be used. General symptoms such as poor appetite likely. When provided free choice to ruminants on a good ration, acute poisoning not likely.

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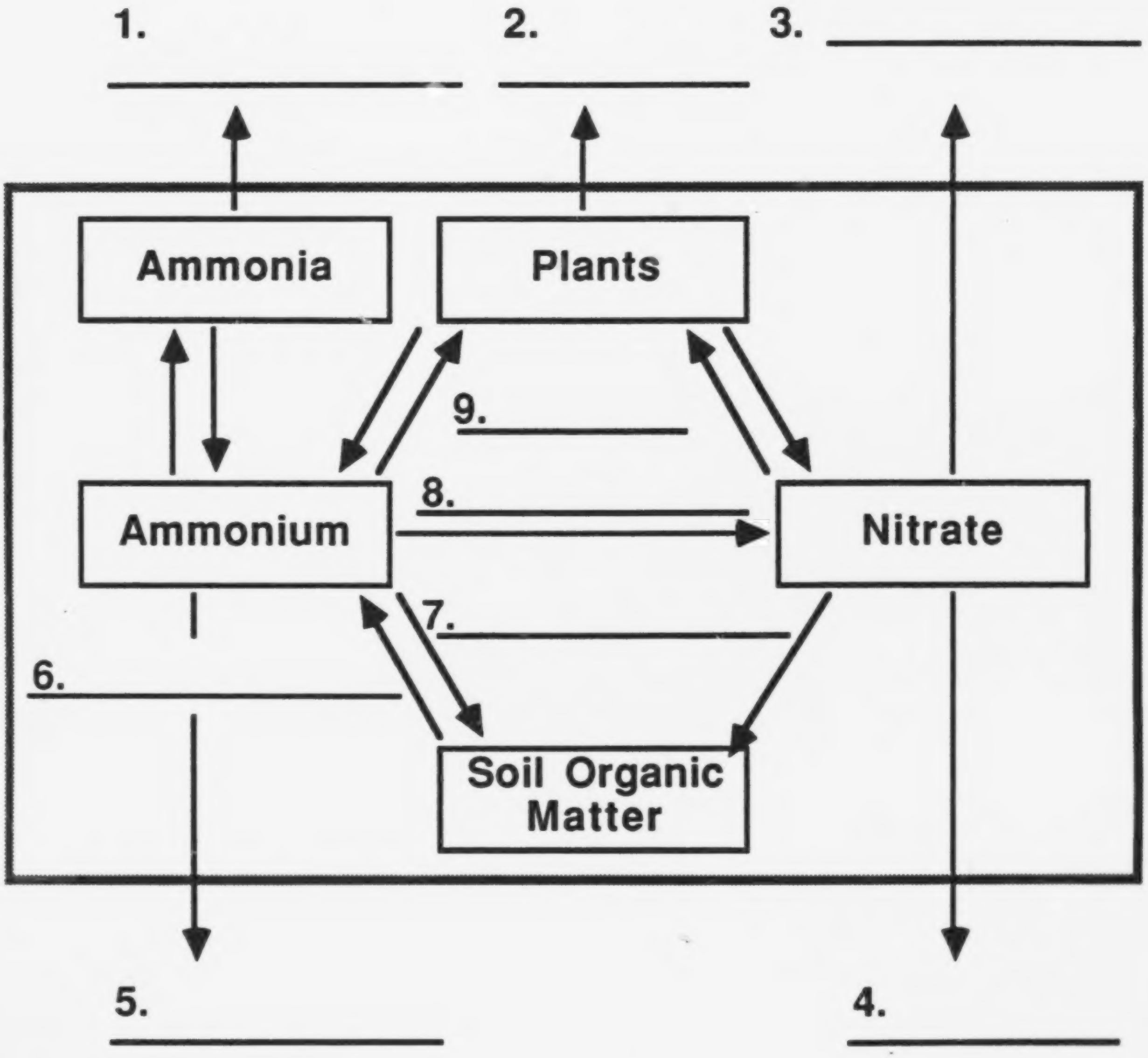
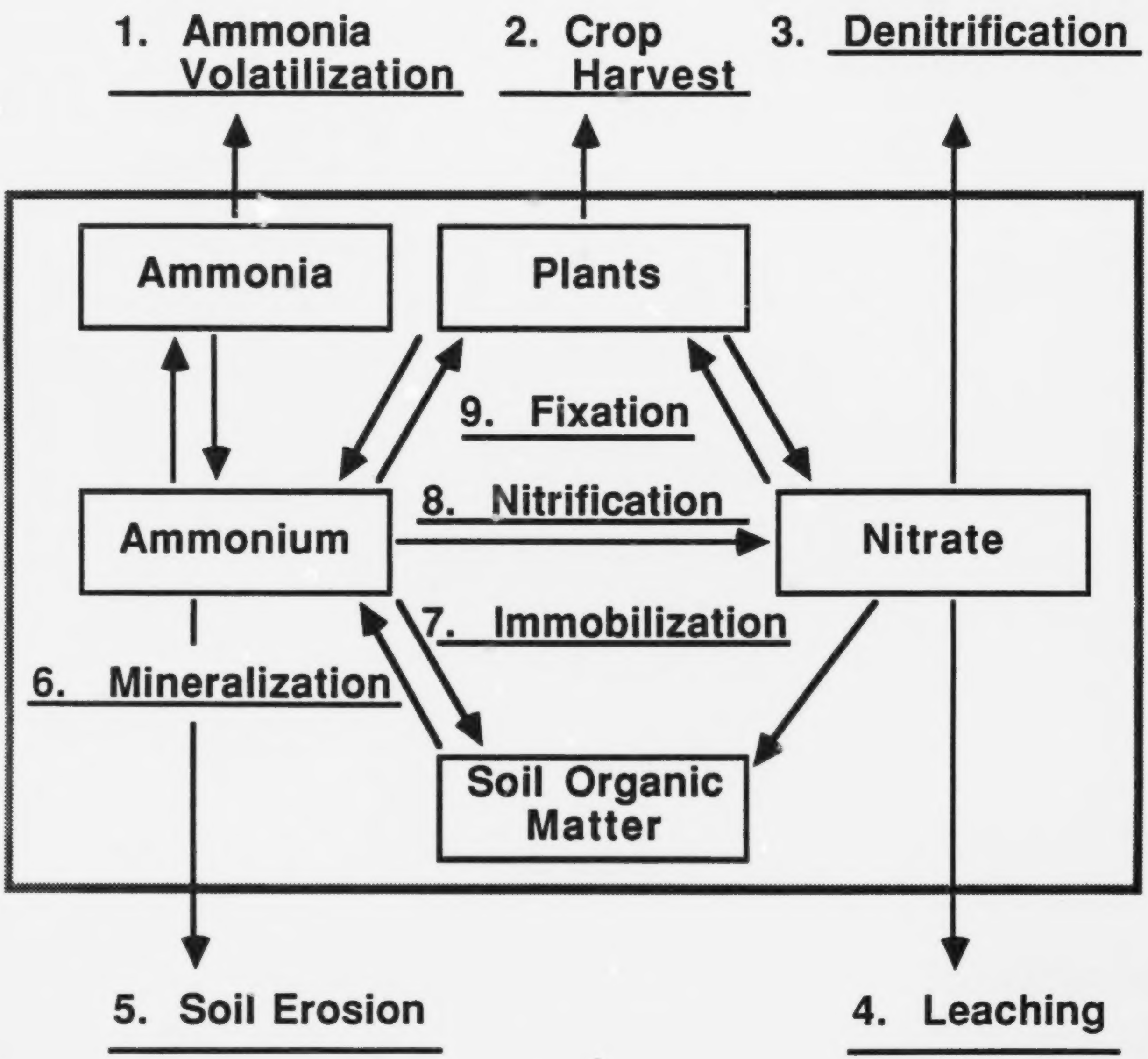
* G3217; Nitrate, Groundwater, and Livestock Health, University of Wisconsin Extension

Nitrogen Cycle Leading to Losses of N from Soils


1. ____
2. ____
3. ____
Ammonia
Plants
9. ____
8. ____
Ammonium
Nitrate
7. ____
6. ____
Soil Organic Matter
5. ____
4. ____

Nitrogen Cycle Leading to Losses of N from Soils


1. Ammonia Volatilization
2. Crop Harvest
3. Denitrification
Ammonia
Plants
9. Fixation
8. Nitrification
Ammonium
Nitrate
7. Immobilization
6. Mineralization
Soil Organic Matter
5. Soil Erosion
4. Leaching

Management and terms

Following is a list of terms associated with nutrient application movement of the nitrogen in the soil.

For the farmer to minimize water pollution, he/she must look at the total picture. All the elements that contribute to nutrient losses should be examined and taken into account when one plans a management program to reduce nutrient movement into water reserves.

Alluvium - parent material deposited by moving water. Alluvial parent materials are found in flood plains. If this parent material is the type to be farmed, it would be sound management to apply nutrients in stages and not make the nutrients subject to flooding. Alluvial parent materials can be stratified and sorted. Stratification and sorting lead to different soil textures that may occur within close proximity to each other. This means that a coarse textured soil can exist next to a fine textured soil. If farmed to satisfy the characteristics of the fine textured soil, the nutrient application would be more susceptible to leaching in the coarse textured soil where the water movement through the soil is greater and will contribute to leaching losses of nutrients.

Bedrock - The solid rock that underlies the soil and other unconsolidated material or that is exposed at the soil surface. Bedrock is fairly impermeable and soils that have bedrock as part of their profile will have problems with erosion and/or leaching. This results from the properties of the bedrock from which the soil developed. If developed from sandstone, the soil would be more permeable and more susceptible to leaching losses.

Denitrification - The reduction of nitrates to nitrogen gas as an end-product. The denitrification process can result in less nitrogen movement into the groundwater but also results in nitrogen unavailability to the plant. Denitrification is generally caused by saturated conditions in the soil. Loss through denitrification is generally compensated for by the application of heavier rates of nitrogen fertilizer. When conditions for denitrification do not occur, the heavier application results in more availability of the nitrogen to move into groundwater reserves.

Drainage class - The frequency and duration of saturation or partial saturation. The drainage class also has an effect on both the erosion potential and the leaching potential of a soil. Well-drained soils would be more susceptible to leaching losses and poorly drained soils would be more susceptible to erosion losses. Again, this cannot be separated from the other soil properties and the management system that examines the total picture will reduce nutrient movement into groundwater reserves.

Fixation - The conversion of elemental nitrogen from the atmosphere to organic combinations or to forms readily used in biological processes. Normally carried out by bacteria, either living with legumes or by free living soil bacteria. Bacteria in conjunction with legumes (symbiotic) and bacteria free-living in the soil (non-symbiotic) are capable of this conversion and management practices which use this fixation should be considered in the farmers' management program.

Glacial till - parent material deposited by glacial movement and melt. The soils developed from glacial till are variable in their texture and structure. Because of this variability, the nutrient loss is more dependent on the properties of each soil and management programs need to take into account the composition of the specific till material from which the soil developed.

Immobilization - mineral forms of nitrogen are taken up by the plants and incorporated into their tissue. This process prevents the availability of nitrogen for movement into water reserves.

Infiltration - The downward entry of water into the immediate surface of the soil or other material, as contrasted with percolation, which is movement of water through soil layers or materials.

Leaching - the removal of soluble material from soil and other materials by water moving down through the soil profile. The soluble form of nitrogen is the nitrate form. The conversion of the ammonium form (non-soluble) of nitrogen to the nitrate form could result in groundwater pollution. Management practices to minimize leaching would include a knowledge of the soils on the piece of land to be farmed, i.e. the drainage class, the permeability, the slope, the susceptibility to flooding, the time of application, the rate of application, and the method of application.

Loess - Parent material deposited by wind. Loess, because it is deposited by wind, has to be managed such that structure is not destroyed. Most loess soils have good structure because of the effect of the clay in the parent material, but this structure can be easily destroyed without proper management. Many of the management techniques for these soils parallel those of others.

Mineralization - The process of converting an organic form of nitrogen into the mineral form.

Nitrification - A two step process in which the insoluble ammonium form is changed into the soluble nitrate form. This two step process is done by bacteria in the soil. The inhibition of this conversion is the control of the bacteria that make this conversion. N-Serve is a common commercial product that limits the action of one of the bacterium and leaves the nitrogen in the ammonium form and not susceptible to leaching.

Organic matter - chemical substance of animal or plant origin. Incorporation of organic matter into the soil promotes soil structure which can or cannot contribute to leaching losses but it does have a definite influence on the infiltration of the precipitation into the soil. This infiltration has a definite impact on the erosion process because it prevents water movement and the carry of sediments to the water reserves.

Outwash - material deposited by glacial movement and then separated from the finer particles by the melt of the glacier. Very highly permeable soils and any type of nutrient application can result in losses to both erosion and leaching.

Parent material - The unconsolidated mineral or organic material from which a soil forms. Parent material affects the structure and the texture of the soils on the site. Soils developed from a sandy soil texture would be more susceptible to leaching losses. Soils with developed structure could also be susceptible to leaching because the channels necessary for leaching would be influenced by the size of the soil aggregates. Management of soils on different parent materials is dependent on the material the soil developed from.

Permeability - The capacity of a porous rock, sediment, or soil for transmitting fluid. A measure of the relative ease of fluid flow under pressure. The greater the permeability the more potential for leaching losses. This is generally related to the texture and structure of the soil. This can be improved by the incorporation of organic matter into the soil and this incorporation prevents runoff but may result in more leaching.

Slope - The inclination of the land surface from the horizontal. The slope of the soils on a site can influence both leaching losses and erosion losses of nitrogen to the water reserves. If the soil has an A slope (0-2%), precipitation often leaches the soluble nitrogen from the soil but erosion is minimized. If the slope is steeper, loss of nitrogen is generally through erosion. Slope in conjunction with drainage class and permeability can be used to determine the possibility of movement of applied nutrients either through leaching or erosion. Management practices that use all the information available could eventually ease the concern of nutrient movement into the water reserves.

Structure - The arrangement of primary soil particles into compound particles or aggregates. Structure has a significant role in the movement of water into and through the soil. On one hand this inhibits erosion losses because the water enters the soil but can also promote leaching losses if nutrient application is made just before a heavy rain.

Texture - The relative amounts of sand, silt and clay in a given soil. Sandy soils will leach more than silt or clay soils. Nutrient application would have to be timed such that nutrient loss in sandy soils would be minimized. You should not fertilize just before a heavy rain is expected.

Volatilization - Loss of a substance through evaporation or change from a non-vaporous state to a vaporous state. Nitrogen fertilizers, both natural and chemical can volatilize under certain conditions. When volatilization takes place and nitrogen deficiencies in the plant are shown, the farmer might compensate for the loss by heavier applications of nitrogen fertilizers

Weathered till (paleosol) - A soil that formed during the geological past and was buried and preserved by more recent sedimentation. Often exposed on the surface by subsequent erosion. These soils are highly impermeable so the contribution to water pollution would be more severe as a result of erosion rather than leaching.

Weathering - Physical and chemical changes in rocks or other deposits that result in the breakdown of that material.

Soil Characteristics are important because they have a significant effect on the amount of leaching of chemicals that may occur. Knowledge of the soils in your area will help you to develop a nitrogen management program for your area.

Matching: Choose the one best phrase for each term.

Soil Property Influence on Nitrogen Movement in Soil

1. ____ Slope
2. ____ Rainfall
3. ____ Weathering
4. ____ Drainage Class
5. ____ Parent Material
6. ____ Organic Matter
7. ____ Permeability
8. ____ Texture
9. ____ Structure
10. ____ Infiltration

a. Allows water to move around the soil particles
b. Allows water to move around the soil aggregates
c. Unconsolidated material
d. Influence of time
e. Biological and holds nitrogen on their surfaces
f. Rate at which water moves through the soil
g. Ability of the water to flow down through the soil
h. Takes into account internal drainage
i. Frequency and duration important
j. Influences water movement by landscape position

Parent Material Effects on Soluble Nitrate Movement

1. ____ Loess
2. ____ Alluvium
3. ____ Glacial Till
4. ____ Bedrock
5. ____ Weathered Till
6. ____ Outwash

a. Is variable in texture, contains stones and allows easy nitrate movement
b. Its texture is the biggest factor affecting nitrate movement
c. Its a shallow soil that allows nitrate movement
d. Both structure as well as texture affects nitrate movement
e. Nitrate movement should be lateral instead of vertical
f. Nitrate moves easily with the water table

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Soil Property Influence on Nitrogen Movement in Soil

1. j Slope
2. i Rainfall
3. d Weathering
4. h Drainage Class
5. c Parent Material
6. e Organic Matter
7. g Permeability
8. a Texture
9. b Structure
10. f Infiltration

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ACT-NIT-4

7 Steps to Increase Nitrogen Efficiency While Reducing Environmental Risks

I want to apply nitrogen fertilizer for my next corn crop. I have been applying 180 pounds of nitrogen since 1983 and have been satisfied with the yields that I have been receiving. I have read about the groundwater quality problem in Iowa and that nitrates are a cause for some concern. My question is: how do I increase the efficiency of the nitrogen that I put on and at the same time reduce any environmental problems that I may be creating?

Listed below are seven steps that should give the type of nitrogen management system this individual requires. Each of these steps increase the efficiency of nitrogen application and reduce environmental risks.

Your task is to use each of the following steps to develop the type of management system this individual wants.

1. Establish Realistic Yield Goals - From Handout- ACT-NIT-4, calculate the recommended nitrogen application rates for your county.
2. Soil Test
3. Sidedress or Split Applications
4. Use Ammonium Form of Nitrogen
5. Use Nitrification Inhibitors
6. Incorporate
7. Manage for Total Nitrogen Use

7 Steps to Increase Nitrogen Efficiency While Reducing Environmental Risks

1. Establish Realistic Yield Goals - Recognize that exceptionally good years are the exception. Establish realistic yield estimate for each field based on past performance and then fertilize accordingly. View Nitrogen usage in terms of pounds of nitrogen required per bushel of grain. Resist the temptation to apply extra nitrogen that could increase the potential for nitrate pollution in most years.

2. Soil Test - Most states have data on rates of Nitrogen required to achieve target yields as well as adjustments needed to account for use of manures and legume crops. However, if you are unsure of residual nitrogen amounts currently available in a field, soil testing could be a wise investment, especially in drier areas west of the Missouri River. Analysis of irrigation water for nitrate concentration is also recommended.

3. Sidedress or Split Applications - Losses due to denitrification, leaching, and soil erosion can be reduced by sidedressing or splitting nitrogen applications, which can reduce applications of "insurance" nitrogen.

4. Use Ammonium Form of Nitrogen - When nitrogen applications are made well ahead of maximum crop use, ammonium forms, such as anhydrous ammonia, can help reduce losses. Because ammonium fertilizers tend to bind with clay particles in the soil, the risk of leaching is reduced.

5. Use Nitrification Inhibitors - Nitrification inhibtors are beneficial in keeping nitrogen in the ammonium form for longer periods of time. This is commonly referred to as stabilized nitrogen. Nitrification inhibitors are recommended when soil type, moisture conditions and temperatures are conducive to leaching or denitrification losses.

6. Incorporate - Incorporating nitrogen fertilizers will reduce nitrogen losses caused by surface runoff and erosion. Perhaps, even more important, incorporation can reduce volatilization losses from urea, too.

7. Manage for Total Nitrogen Use - Manage all elements of crop production, including nutrients other than nitrogen, to meet your yield goals, In this way, low yields that result in only partial use of nitrogen and increase risk of nitrogen loss can be avoided.

* Treasure of Abundance or Pandora's Box? Soil and Water Conservation Society.

Establishing Sound Nitrogen Management Programs on Cropland*

Management is used to decrease the loss of nutrients to water reserves but still provide optimum amounts of plant nutrients for crop production. It includes rates, placement, timing, and type of fertilizer. Nitrogen management is the key in controlling pollution of waters by agricultural nitrogen applications.

As attempts are made to balance concerns, it must remembered that no single management practice is best. A management practice for one situation may be wrong for another. The problem must be identified and reviewed and then the best management should be used. The following is a checklist of management practices that should be considered for nitrogen management programs in Iowa.

1. Set realistic yield goals with use of modern soil surveys

Because nitrogen recommendations are based on a yield goal, setting a *realistic* yield goal will eliminate applications of nitrogen that could pollute. Studies have shown that some producers apply more nitrogen than needed. Modern soil surveys are available for most counties in Iowa as well as a list of the yield potential of all soils mapped in the state. This information can be used to determine a realistic yield goal and apply a rate of nitrogen based on that yield goal.

Nitrogen rates are significant in the control of the losses to water reserves. Fertilizers should not be used unless needed. Excessive applications must be avoided.

Table 1. Nitrogen recommendations procedure for corn and sorghum based on yield goal (YG) and factors for soil areas. The recommendations should be rounded to the nearest unit of five (Killorn, 1988b).

Soil Area	Soil Associations	Yield Goal bu/acre	N Equation
0	Clarion-Nicolet-Webster Kenyon-Floyd-Clyde Cresco-Lourdes-Clyde	≤ 150	lbs N/a = Yield Goal (bu/a) x 1.2 lbs N/bu Ex: Yield Goal =140: 140 x 1.2 = 168 or 170 lbs N/a
1	Tama-Muscatine Dinsdale-Tama Fayette Downs	151-180	lbs N/a = 180 + (YG - 150) x 1.3 lbs N/bu Ex: YG =160: 180 +[(160-150) x 1.3] = 193 or 195 lbs N/a
		> 180	lbs N/a = 220 + (YG - 180) x 1.4 lbs N/bu Ex: YG = 200: 220 +[(200 -180) x 1.4] = 248 or 250 lbs N/a
2	Otley-Mahaska-Taintor Clinton-Keswick-Lindley		
3	Adair-Grundy-Haig Adair-Seymour-Edina Grundy-Haig Lindley-Keswick-Weller		
4	Shelby-Sharpsburg-Macksburg		
9	Luton-Onawa-Salix		
	Irrigated corn in all areas		
5	Marshall	any	lbs N/a = Yield Goal (bu/a) x 1.1 lbs N/bu Ex: Yield Goal =160: 160 x 1.1 = 176 or 175 lbs N/a
6	Monona-Ida-Hamburg		
7	Galva-Primghar-Sac		
8	Moody	any	lbs N/a = Yield Goal (bu/a) x 0.9 lbs N/bu Ex: Yield Goal =160: 160 x 0.9 = 144 or 145 lbs N/a

Table 2. Nitrogen recommendations procedure for all soil areas for oats, wheat, and sunflowers based on yield goal (YG) and factors. The recommendations should be rounded to the nearest unit of five. (Killorn, 1988b).

Crop	N Equation
Oats	lbs N/a = Yield Goal (bu/a) x 0.75 lbs N/bu Ex: Yield Goal = 50 bu: 50 x 0.75 = 37.5 or 40 lbs N/a
Wheat	lbs N/a = Yield Goal (bu/a) x 1.3 lbs N/bu Ex: Yield Goal = : 50 x 1.3 = 65 lbs N/a
Sunflowers	lbs N/a = Yield Goal (lbs/a) x 3.5 N/100 lbs Ex: Yield Goal =1250 lbs: 12.5 x 3.5 = 43.75 or 45 lbs N/a

Table 3. Amounts of nitrogen to be subtracted from recommended nitrogen rates if a grain crop follows forage legume or soybeans. (Killorn 1988b).

Pounds of nitrogen to be subtracted for grain crop following legume		
1st year grain crop	2nd year grain crop	Legume
140	30	50-100% stand of forage legume
100	0	20-50% stand of forage legume
100	0	legume green manure
1 lb N/bu soybeans	0	soybeans

2. Soil test measurements

If reliable soil test measurements can be developed for Iowa conditions, they can be used to determine the amount of nitrogen recommended. Research is currently under way to calibrate soil and tissue nitrate tests. Plant measurements of nitrogen have been related to yield. Grain nitrogen at harvest, stem nitrate in early season corn, and nitrogen concentration in the ear leaf at silking have been related to yield but *these measurements do not permit adjustment of the current year's nitrogen program.*

3. Pre-plant versus sidedress nitrogen

If conditions for leaching losses occur following pre-plant applications of nitrogen, then sidedressing nitrogen should be more efficient. If conditions for leaching losses of nitrate do not occur, there should be no difference between the efficiencies of pre-plant and sidedress applications of nitrogen. If sidedressed too late or to a dry soil, there is a chance that it will not be used efficiently as would a pre-plant application. This may result in reduced yields and greater losses in the fall compared to a pre-plant application. Which time of application may be superior can be based on the long-term frequency of water moving through the soil profile during the May-June period, but for any *given year and site* the prediction may be in error.

Fertilizer timing can be effective in reducing nitrogen pollution. Nitrogen should be applied as close to plant demand periods as possible. Fall and early spring applications are made in order to avoid the competition for labor and equipment which occurs if the application is delayed until spring. Fall applications for the spring season can be leached below the root zone before the season begins if there is considerable winter precipitation. If fall applications of nitrogen are necessary, ammonia forms should be selected to minimize leaching. They should be applied after the soil has cooled to 50° F to a depth of 4 inches to prevent conversion to the readily mobile nitrate form. Early spring applications can also result in considerable losses as a result of movement from heavy rainfall.

For crops such as corn, the most efficient use of nitrogen is accomplished by using a light pre-plant application followed by sidedress applications when the crop reaches knee height.

4. Source of nitrogen. i.e. nitrate versus ammonium

Fertilizer source comparisons provide a variety of results depending on method and time of application, physical and chemical characteristics of the soil, nitrogen needs of the crop, gaseous characteristics of the fertilizer source, and temperature and precipitation after application. If leaching conditions occur after application, the nitrogen source remaining in the ammonium form will usually produce the greatest test yield. Nitrate forms should not be applied to sandy soils or under conditions where leaching losses are probable. Ammonium (or ammonium-forming) fertilizers must change to nitrate before they can be leached through soil. Anhydrous ammonia has an effect on nitrification that tends to delay the total amount of ammonium nitrified relative to other nitrogen sources. The ammonia fertilizer nitrogen sources used over an extended period of time have not produced any effects on soil characteristics.

The fertilizer type can be an aid in reducing pollution. Fertilizers are available in granular, gaseous, liquid, suspension, or slurry forms. When the pollution pathway has been determined, a fertilizer can be selected that will reduce the pollution potential. As previously stated, nitrate forms are highly soluble, and fall applications should be avoided where leaching is a problem. Some nitrogen compounds are available that release their nitrogen over a long period of time. These fertilizers are intended to constantly supply nitrogen as it is needed by the plants; however, they generally are more expensive.

5. Use of N-Serve as a nitrification inhibitor

N-Serve prevents the conversion of ammonium to nitrate. Use of N-Serve with fall applied ammonia has not resulted in consistent crop yield responses,in Iowa and frequently a spring application of nitrogen produces greater yields than a fall application with or without N-Serve, responses on fine textured or heavy soils are unpredictable. Nitrification inhibitors slow the rate at which the ammonium form is changed to the nitrate form. This will reduce nitrogen loss when conditions are favorable for leaching and denitrification.

6. Incorporate

The method of application has an impact on the quantity of nutrients lost in runoff from a field or pasture. If practical, all fertilizer should be incorporated to reduce the loss by volatilization and runoff. Fertilizers are incorporated by disking or plowdown and by injection.

It may not be possible to incorporate the nutrients on pasture and grassland. When surface application is necessary, it should be scheduled to reduce nutrient losses caused by rain or snowmelt. Soluble fertilizers should be considered for surface application. They provide higher infiltration thereby reducing surface runoff losses. If a crop is to be irrigated, the fertilizer can be injected into the water; however, there should be no runoff during irrigation.

ESTABLISHING SOUND NITROGEN MANAGEMENT PROGRAMS ON CROPLAND

1. SET REALISTIC YIELD GOALS WITH THE USE OF MODERN SOIL SURVEYS

2. SOIL TEST MEASUREMENTS

3. PRE-PLANT VERSUS SIDEDRESS NITROGEN

4. SOURCE OF NITROGEN. I.E. NITRATE VERSUS AMMONIUM

5. USE OF N-SERVE AS A NITRIFICATION INHIBITOR

6. INCORPORATE

7. MANAGE FOR TOTAL NITROGEN USE

There are many management practices used to minimize nitrogen movement into water reserves. Some of these are 1) conservation tillage, 2) terraces, 3) contour farming, 4) strip cropping, 5) field borders, 6) irrigation water management, 7) cover or green manure crops, and 8) filter strips.

7. Manage for total nitrogen use

A proper balance of essential nutrients and soil moisture is needed to ensure proper plant growth. A deficiency of one element may reduce the plant uptake of other nutrients, thus making them available as pollutants. Soil tests are probably the most important guide to the proper use of fertilizers. These tests, combined with information about soil type, previous cropping, and the anticipated soil moisture level, should be used to estimate fertilizer requirements. Fertilizer rates should be based on reasonable yield goals. Excessive application of nutrients, especially nitrogen must be avoided.

A conservation cropping system can aid both water quality and agricultural production. It improves soil structure, which increases filtration, decreases runoff, and increases aggregate stability. In a continuous cropping system such as corn, nitrogen buildup is often the source of nutrient pollution. Using crop rotations can reduce buildup of nitrogen as a pollutant. Using crops that require little or no nitrogen in rotation with crops requiring large amounts of nitrogen (corn-bean rotation) reduces the potential for nutrient loss.

Grasses and legumes in rotation can reduce nutrient losses, aid in improving soil structure, and provide large amounts of nitrogen for use by the succeeding crops. A deep-rooted crop like alfalfa or a perennial grass can use nitrates below the normal root zone of other crops and reduce nitrate leaching.

Legumes are nitrogen-fixing plants that with their related bacteria use nitrogen from the air. The amount of nitrogen fixed depends on the type of legume and the environmental conditions. Annual nitrogen fixation is generally in the range of 30 to 100 lbs/acre although as much as 420 lbs/acre have been reported. If the legume is left in the rotation for two or more years, significant quantities of nitrogen will be available for use by successive crops. This will greatly reduce the need for commercial nitrogen fertilizer. Nitrogen can be lost as the legume decomposes, but it is not as available for detachment or transport as are large applications of commercial fertilizer.

There are many ways to manage to minimize nitrogen movement into water reserves. Some of these are 1) conservation tillage, 2) terraces, 3) contour farming, 4) strip cropping, 5) field borders, 6) irrigation water management, 7) cover or green manure crops, and 8) filter strips.

A sound nitrogen management program will reduce potential nitrates from entering groundwater and with less need for chemical nitrogen, will reduce energy needed for the manufacture of and transportation of the chemical nitrogen.

*SCS Water Quality Guide and Best Management Practices to Control Groundwater Quality in Iowa.

ACT-NIT-5

NITROGEN - HEALTH CONCERNS EXERCISE

Group A: You are assigned to a task force of agricultural leaders, given the responsibility of analyzing the correlation between the increased use of nitrogen fertilizers and the reports of more frequent high nitrate concentrations in drinking water. You are to prepare reasons and recommendations as to how to develop an educational program for your community to:

1. make the public aware of the facts.
2. identify farming practices that would reduce nitrate contamination.
3. identify areas of concern where additional study and research is needed.

Group B: You are assigned to a task force of concerned taxpayers with the responsibility of weighing the issues of using tax dollars for additional nitrate related research.

Prepare a list of reasons why more funds should be spent on this research and another list on why funds should not be spent on this issue. After looking at both sides of the issue, prepare your recommendations.

ACT-NIT-6

Field 1 Corn	Field 2 Soybeans
Field 4 Meadow	Field 3 Oats

You are the owner of a 640 acre farm. The farm is divided into 4 fields. The time has come to order your nitrogen fertilizer from the local co-op. Previously you have applied 230 lbs N/a on the field to be planted in corn and 60 lbs/a on the field to be seeded to oats. You have become aware of the groundwater problem caused by the application of too much nitrogen and you decide to try to apply the correct amount of nitrogen for your established yield goals. You want to average 175 bu/a of corn and 60 bu/a of oats.

The farm is located in the Clarion-Nicollet-Webster soil association and each field consists of 160 acres. This is only the second year that meadow has been included in the rotation so the rotation is now corn-soybeans-oats-meadow.

Cropping History

Field 1: Field 1 will be planted to corn this year. Last year Field 1 was in alfalfa. The stand of alfalfa was not the best as there was only a 75% stand of alfalfa.

Field 2: Field 2 will be planted to soybeans. Last year the field was in corn and had an average yield of 178 bu/a.

Field 3: Field 3 will be seeded to oats. Last year the field was in soybeans and had an average yield of 38 bu/a.

Field 4: Field 4 will be in alfalfa meadow. It was seeded to alfalfa with the oats last year and had an average oat yield of 63 bu/a.

There are three questions to be answered:

1. Was I applying the correct amount of nitrogen for the crops and my stated yield goals?
2. If the rates of nitrogen application are not correct, what should they be for the corn and oat fields for the next growing season?
3. How much will I save on on my nitrogen bill by incorporating a meadow into the rotation, allowing for legume credits, and applying the recommended rate of nitrogen fertilizer for my stated yield goals? (Nitrogen sells for 25 cents/lb)

Use the cropping history and the tables in INFO-NIT-5 to calculate the total amount of nitrogen that will need to be ordered from the co-op.

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Field 2: Field 2 will be planted to soybeans. Last year the field was in corn and had an average yield of 178 bu/a.

Field 3: Field 3 will be seeded to oats. Last year the field was in soybeans and had an average yield of 38 bu/a.

Field 4: Field 4 will be in alfalfa meadow. It was seeded to alfalfa with the oats last year and had an average oat yield of 63 bu/a.

There are three questions to be answered:

1. Was I applying the correct amount of nitrogen for the crops and my stated yield goals?

Recommended: lbs N/a (oats) = Yield Goal x 0.75, 60 bu/a x 0.75 = 45 lbs/a for oats

lbs N/a [(corn, soil area 0), Yield Goal =175] = 180 + [(Yield Goal - 150) x 1.3]

180 + [(175-150) x 1.3] = 212.5 lbs or 215 lbs N/a

2. If the rates of nitrogen application are not correct, what should they be for the corn and oat fields for the next growing season?

Legume credit:

Oats following soybeans = 1 lb/bu soybean yield or 38 lbs/a N, 45 lbs/a - 38 lbs/a = 7lbs/a for oats

Corn following meadow = 140 lbs/a for 75% forage stand for first year following meadow
or 215 lbs/a - 140 lbs/a = 75lbs/a for corn.

Total: 160 acres x 7 lbs/a = 1120 lbs for oat field, 160 acres x 75 lbs/a = 12000 lbs for corn field = 13120 lbs

3. How much will I save on on my nitrogen bill by incorporating a meadow into the rotation allowing for legume credits and applying the recommended rate of nitrogen fertilizer for my stated yield goals? (Nitrogen sells for 25 cents/lb)

Past : (160 x 230) + (160 x 60) = 46,400 lbs **Adjusted:** (75+7) x 160 = 13120 lbs

Savings: 46400 - 13120 = 32280, 32280 x .25 = $ 8070

Use the cropping history and the tables in INFO-NIT-5 to calculate the total amount of nitrogen that will need to be ordered from the co-op.

The nitrogen requirement for the oats and corn went from 46,400 lbs to 13,120 lbs by using recommended rates, legume credits and the inclusion of a meadow in the rotation. This reduced the nitrogen bill by $8070.

ACT-NIT-7a

Your local FFA chapter has decided they should examine the groundwater pollution problem caused by nitrogen fertilizer use. There has been much discussion about the problem and some questions were raised that need to be answered. These questions were divided into three areas of discussion. These areas are: 1) production agriculture, 2) energy and economics, 3) and the social, moral and ethical issues.

Your chapter has decided to publish a brochure about the nitrogen problem. Your FFA chapter has decided to break into three groups with each group looking at one of the three areas. Each group will then be responsible for reporting to the chapter their findings and conclusions. For the sake of time, each **group** will be allowed 15 minutes for an oral presentation. Each groups findings will then be discussed by the whole chapter. The following topic was assigned to your group.

PRODUCTION AGRICULTURE

1. Time of nitrogen application - When?
2. Rate of nitrogen application - How much?
3. Placement location - Where?
4. Economics - Savings?
5. Environmental - Pollution?
6. Type of nitrogen fertilizer to be used - ammonia versus nitrate?
7. Nitrification inhibitors - N-Serve?
8. Root damage caused by sidedressing?
9. Importance - Other aspects of fertilizer programs that may be more important?
10. Energy savings - How will this result in any overall energy savings?
11. Soil Changes - any detrimental effect to the soil by these changes?

Possible topics or questions for discussion.

1. How will timely application (application during rapid growth stage) change present nitrogen management systems?

2. Banding; with rate, time and placement implications, may or may not have detrimental effects on the soil. Relate the possible detrimental effects from the practice of banding.

3. One person says that it is not feasible to band fertilizers. Another says that banding of nitrogen fertilizers could ease some of the problems caused by farming. Who do you agree with and why?

4. "I have to fertilizer for the highest possible yield because I need the money that high yields will bring and it is possible that this might be the year when conditions are right for the high yields." Discuss the pros and cons of this type of thinking.

5. Would a switch to reduced tillage affect nitrogen contamination of groundwater?

6. Should the contamination of our groundwater be given the priority it is now receiving? Are there other management issues more important than groundwater quality?

7. How much of the available nitrogen (applied and natural) in the soil is used by the plant?

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ENERGY AND ECONOMICS

1. Time of nitrogen application - When?
2. Rate of nitrogen application - How much?
3. Type of nitrogen fertilizer to be used - ammonia versus nitrate?
4. Energy savings - How will this result in any overall energy savings?

Possible topics or questions for discussion.

1. Correlate the change in total energy use on the farm and in the production of fertilizers to timely applications of nitrogen fertilizer.
2. Discuss some of the economic advantages and disadvantages of broadcast and banded nitrogen fertilizers.
3. One person says that it not feasible to band fertilizers. Another says that the banding of nitrogen fertilizers could ease some of the expenses in farming. Who do you agree with and why?
4. Are there economic advantages to the banding practice for fertilizers? Would these advantages also apply to all pesticide applications?
5. Changes in any system mandate new skills. The acquisition of those skills usually results in mistakes and the mistakes generally mean decreased profits. What is the responsibility of the farmer in the absorption of these losses? the community? the county government? the federal government?
6. Will reduced application of nitrogen fertilizers affect community economic viability because of decreased yields?
7. Should government subsidies be used to encourage the farmer to adopt a more efficient fertilizer program?
8. Is absolutely clean groundwater necessary?
9. Would more precise applications (rate and timing) be worth the added time, cost, and effort?

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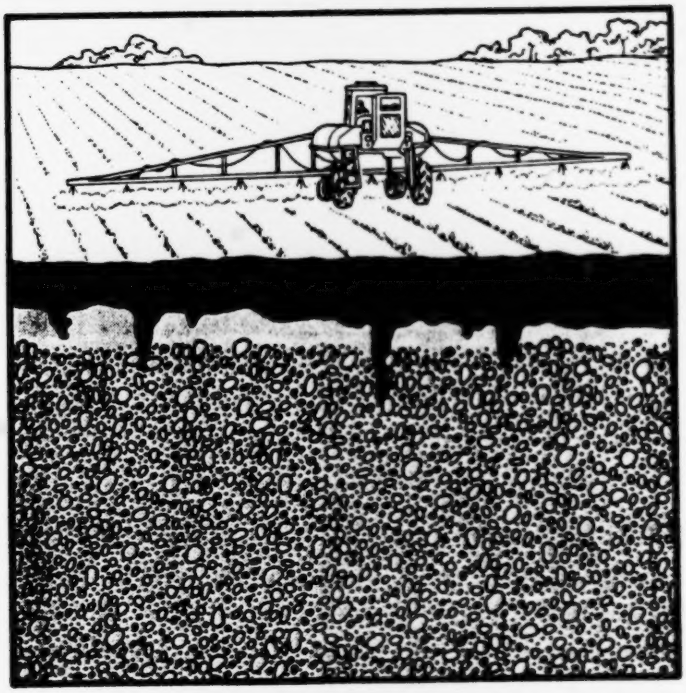
SOCIAL, MORAL, and ETHICAL

The following may be from a list of the thoughts that may have occurred to you.

1. Who should gain and who should be responsible for environmental accidents caused by practices that increase production?
2. Should the legislature mandate fertilizer management practices since the problem is so widespread?
3. Changes in any system usually mandate that new skills be learned. The acquisition of those skills usually results in mistakes that generally decrease profits. What is the responsibility of the farmer in the absorption of these losses? the community? the county government? the federal government?
4. Does the farmer have the moral responsibility for his/her possible contamination of groundwater reserves from his/her fertilizer program? If not, then who?
5. Who is responsible to pay for damages caused by nitrogen fertilizer application?
6. Should subsidies be used to encourage the farmer to adopt more efficient fertilizer programs?
7. Should the contamination of our groundwater be given the priority it is receiving? Are there other agricultural issues more important than groundwater quality?
8. Is the groundwater quality issue being sensationalized and is it or is it not as critical as reported?
9. Is it moral for legislators to direct how an individual can use their own land? Is this an issue that supersedes the moral issue because a fertilizer program in one part of the state could affect groundwater quality in another part of the state or the nation?
10. When are the individual rights of the farmer less important than the safety of a community?
11. Should environmental standards be relaxed in order to achieve economic growth?
12. One study has shown that farm operators think that profitability in agriculture as well as soil erosion is more important than groundwater quality. How do you feel about these issues?
13. Public education will alleviate many of the worries of those not involved in farming. Respond.
14. What should be the role of the Federal Environmental Protection Agency in this problem?
15. Who should fund the research necessary for development of fertilizer management practices that contribute less to the groundwater contamination problem? Industries? Universities? State governments? the Federal government?

MANAGING AGRICULTURAL PESTICIDES



EDUCATIONAL CONCEPTS

- How pesticides get into water
- Health effects
- Best farm management practices
- Energy conservation

Unit 5: MANAGING AGRICULTURAL PESTICIDES

Managing Agricultural Pesticides

LESSON 1: Applying Pesticides Safely

GOAL:

Contamination of groundwater by pesticides is a major concern of the citizens in Iowa. Pesticides have been found in the drinking water of many wells throughout the state. This contamination is threatening the quality of one of Iowa's most valued resources - groundwater. Only through diligent and responsible land management can farm operators deter further contamination. All citizens of Iowa need to understand the importance of pesticide management.

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

1. Demonstrate accurate reading of pesticide label directions.
2. Analyze "best management practices" to reduce pesticide use.
3. Identify health risks related to use of pesticides.
4. Analyze the economic savings from reduced pesticide use.
5. Identify ways to reduce environmental risks associated with pesticides.
6. Describe energy savings resulting from reduced use of pesticides.

MATERIALS & REFERENCES:

Pesticides and Groundwater, A Health Concern for the Midwest; Treasurer of Abundance or Pandora's Box? A Guide for Safe Profitable Fertilizer and Pesticide Use; Water Quality Field Guide; Self-Help Checklist for Farmsteads and Farm Fields; Groundwater Flow Model or Video; Groundwater Flow Model Manual.

VISUAL MASTERS:

VM-PEST-1 Distribution of Atrazine in Wells
VM-PEST-2 Soil Surface Materials in Iowa
VM-PEST-3 Map of Integrated Farm Management Demonstration Sites
VM-PEST-4 Map of 1989 Resourceful Farming Demonstrations
VM-PEST-5 Steps to Reduce Groundwater Contamination

ACTIVITIES:

ACT-PEST-1 Corn Budget
ACT-PEST-2 & Key Private Pesticide Applicator Label Worksheet
ACT-PEST-3 & Key Integrated Pest Management
ACT-PEST-4 & Key IPM Decision Making
ACT-PEST-5 & Key Pesticides in Drinking Water
ACT-PEST-6A Ridge-till-planting to Reduce Chemical Use and Save Energy
ACT-PEST-6B Groundwater Quality and Energy Conservation -- Ridge-till, Banding, and Incorporating
ACT-PEST-7 Pesticide Selection Exercise
ACT-PEST-8 Broadcasting and Banding of Pesticides
ACT-PEST-9 Broadcast Sprayer Calibration
ACT-PEST-10 Pesticide Management
ACT-PEST-11 & Key Reducing Groundwater Contamination Exercises

INFORMATION:

INFO-PEST-1 Lasso Label

Prepared by Martin Frick, Department of Agricultural Education, Iowa State University, Ames, Iowa, June, 1989.

INFO-PEST-2	Integrated Pest Management
INFO-PEST-3	Pesticides in Drinking Water
INFO-PEST-4	Best Management Practices
INFO-PEST-5	Pesticide Characteristics and Selection
INFO-PEST-6	Broadcast Sprayer Calibration
INFO-PEST-7	Integrated Farm Management Demonstration Program

INTEREST APPROACH:

Distribute copies of the blank corn budget (ACT-PEST-1) to participants. Instruct students to complete the budget in groups of three. Ask: How much money was attributed to pesticide costs per acre of corn produced? Allow students to reach a consensus on what the normal pesticide costs are in your area. This coupled with fertilizer expenses constitutes a considerable amount of the input costs associated with producing corn. What management practices can be utilized to reduce this cost and at the same time, decrease the risk of groundwater pollution? What other costs would be reduced?

TEACHING PROCEDURES:

1. Review Chapter 10 in the Water Quality Field Guide, and the Pesticide Section in Treasure of Abundance or Pandora's Box for background on controlling pesticide pollution. Distribute pesticide applicator label worksheet (ACT-PEST-2) to participants. Using the label provided (INFO-PEST-1) have participants locate the information from the label needed to fill out the worksheet. Review worksheet answers using KEY-ACT-PEST-2.

2. Use INFO-PEST-2, ACT - PEST-3 and 4 and Keys to develop an understanding of integrated pest management (IPM).

3. Explain that many factors can contribute to pesticide contamination of groundwater. Those factors include geological conditions, soil type, and land topography. Use VM-PEST-1 to determine if wells in your area have tested positive for atrazine. Use VM-PEST-2 to determine if there is any coorelation between soil type in a given area and high or low incidence of wells that have tested positive for atrazine.

4. Using ACT-PEST-5, ask questions related to pesticides in drinking water. Seek trial answers from the participants. Use INFO-PEST-3 to discover the answers and use KEY-ACT-PEST-5 to summarize.

5. Refer to the soil survey for your county to consider possible geological characteristics, soil type and land topography that may contribute to pesticide contamination of groundwater, including wells. Consider the following questions in analyzing why the soils in your area may contribute to groundwater contamination:

   A. What is the organic matter and texture of the soil?
   B. What are the more typical soil textures?
   C. What type of soil structure is predominant?
   D. What is the soil permeability and porosity?
   E. What is the depth of the soil?
   F. How deep is the water table?

6. In small groups, (use INFO-PEST-4 as a reference) have participants list and compare management practices that have the potential to reduce groundwater pollution. Also discuss the economic benefits and energy savings from the practices.

7. In a group discussion, discuss the reasons why a good crop rotation is one management practice to consider in reducing the use of pesticides and in conserving energy? Summarize by writing these key points on the chalkboard: 1) reduces erosion and 2) breaks the life cycles of some pests, reducing the need for pesticides. Crop rotation also reduces

the need for fertilizer when legume crops are included. Energy is conserved when the use of pesticides and chemical fertilizers are reduced.

8. Use ACT-PEST-6A & B to compare ridge-till planting to conventional tillage as a means to reduce pesticide use and conserve energy.

9. Use INFO-PEST-5 in identifying the pesticide characteristics that should be considered in selecting the lowest risk pesticide for a given site and purpose. Use ACT-PEST-7 in selecting a pesticide for a given site.

10. Use ACT-PEST-8 to compare the amount of pesticides required for broadcasting and banding of pesticides. Emphasize economical, environmental and energy implications.

11. Use ACT-PEST-9 and INFO-PEST 6 to identify the steps in calibrating a broadcast sprayer.

12. Use "Pesticides and Groundwater: A Health Concern for the Midwest" to answer the following questions about health and pesticide use: 1) Why can pesticides be a health problem? 2) What are the health implications of pesticides in water supplies? and 3) What can we do to protect our groundwater supplies?

13. Use VM-PEST-3 & 4 and INFO-PEST-7 to discuss demonstrations being conducted in your county. Contact your County Extension Office for specifics. VM-PEST-4 and a list of the 1989 Resourceful Farming Demonstrations are in the appendix.

14. Use ACT-PEST-10 to identify key points that should be included in a pesticide management plan.

15. Have participants complete appropriate portions of Self Help Checklist to analyze their pesticide management procedures.

16. Use ACT-PEST-11 & Key and VM-PEST-5 to apply important management principles learned in this lesson.

OTHER ACTIVITIES:

1. Locate the Integrated Farm Management and Resourceful Farming demonstration sites nearest your school and arrange a field trip for the class.

2. Invite a speaker (from SCS, Extension or other agency) to the class to discuss best management practices for reducing groundwater pollution.

3. Direct the class to write reports or develop a conservation plan using best management practices to reduce groundwater pollution. Involve SCS and other personnel in judging the reports/plans.

SUMMARY:

It is important that the instructions provided on pesticide labels be followed. The need to produce ample supplies of agricultural products and keep groundwater supplies safe from pesticides will require educated and responsible applicators and farm managers. Use biological and cultural methods of pest control before using chemicals. When pesticides become necessary, the user must get the maximum benefit with minimum environmental damage. Integrate selectivity into the pesticide program. Realize that economical control does not require total destruction of the pest -- people can live with a pest population below damaging proportions. Observance of these guidelines can reduce pesticide use. Wise use of pesticides will help agriculture prosper and reduce pesticide pollution of Iowa water resources while conserving energy.

CORN BUDGET*

	Costs of Conventional Management	**Alternative Management
YIELD	________ BU.	________ BU.
PRICE PER BUSHEL	$ ________	$ ________
GROSS INCOME PER ACRE	$ ________	$ ________
VARIABLE COSTS PER ACRE		
SEED	$ ________	$ ________
FERTILIZER AND LIME	$ ________	$ ________
PESTICIDES	$ ________	$ ________
MACHINERY COSTS	$ ________	$ ________
PRODUCTION LABOR	$ ________	$ ________
HARVESTING LABOR	$ ________	$ ________
TOTAL VARIABLE COSTS	$ ________	$ ________
INCOME OVER VARIABLE COSTS	$ ________	$ ________

*Use local variable costs in your budget

**If cost figures on alternative management are not available, discuss how costs could be reduced and at the same time decrease the risk of groundwater pollution.

ACT-PEST-2

Name ____________________

Date ____________________

PRIVATE
PESTICIDE
APPLICATOR LABEL WORKSHEET

Refer to any pesticide label and complete the following questions:

1. What is the trade or brand name? ____________________
2. What is the common name? ____________________
3. What is it? ____________________
(fungicide, herbicide, or insecticide)
4. What is the formulation? ____________________
5. What is the percent active ingredient? ____________________
6. Who manufactures it? ____________________
7. What is the signal word? ____________________
8. How toxic is it? ____________________
(high, moderate, or low)
9. What is the establishment number? ____________________
10. Why is this number important to you? ____________________
____
11. Which crops can it be used on? ____________________
____
12. When should it be used? ____________________
13. Which pests will it control or reduce in Iowa? ____________________
____

(Over)

IC-424E (Revised)
April, 1984

Cooperative Extension Service
Iowa State University
Ames, Iowa 50011

13?

14. What beneficial species will this product injure? ______________

____

15. What is the recommended application rate? ______________________

____

16. Why is this product classified as restricted-use? ______________

____

____

17. What clothing or safety equipment should be worn while handling this pesticide? ____

____

18. In case of contact with this pesticide, what should be done? ___

____

____

19. In case of an emergency, who should be called? ________________

______________________ or ______________________________________

20. How should partially-filled containers be stored? ______________

____

21. What should be done with empty containers? ____________________

____

____

Cooperative Extension Service, Iowa State University of Science and Technology and the United States Department of Agriculture cooperating. Robert L. Crom, director, Ames, Iowa. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914.

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Lasso II
Monsanto
for corn
and soybeans.
50

Las[illegible]

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Lasso® II

GRANULAR HERBICIDE BY **Monsanto**

Selective herbicide for preemergence weed control in corn, soybeans and peanuts.

Read the entire label.
Use only according to label instructions.

Read "LIMIT OF WARRANTY AND LIABILITY" before buying or using. If terms are not acceptable, return at once unopened.

Keep out of reach of children.

CAUTION

IRRITATING TO EYES.
MAY CAUSE ALLERGIC SKIN REACTION.

Avoid contact with eyes and skin.

Avoid breathing dust.

Do not take internally.

In case of contact, flush skin or eyes with plenty of water.

Wash thoroughly after handling.

Launder clothing before re-use.

Avoid contamination of seed, feed, foodstuffs, and fertilizers.

ACTIVE INGREDIENT:	
Alachlor: 2-chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide	15%
INERT INGREDIENTS:	85%
	100%

NET WEIGHT
50
LBS.

In case of emergency involving this product,
Call Collect, day or night, (314) 694-1000

Monsanto

MONSANTO COMPANY
AGRICULTURAL DIVISION
ST. LOUIS, MISSOURI 63166 U.S.A.

U.S. Patent 3,442,945
EPA Reg. No. 524-296-AA

1. LIMIT OF WARRANTY AND LIABILITY

This company warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes set forth in the Complete Directions for Use, when used in accordance with the Directions under the conditions described therein. NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE. This warranty is also subject to the conditions and limitations stated herein.

Buyer and all users shall promptly notify this company of any claims whether based in contract, negligence, strict liability, other tort or otherwise.

Buyer and all users are responsible for all loss or damage from use or handling which results from conditions beyond the control of this company, including but not limited to incompatibility with products other than those set forth in the Directions, unusual weather (i. weather conditions which are outside the range considered normal at the application site and for the time period when the product is applied with the normal range being determined on the basis of the average range for the prior 40 years computed from the best available information, and ii. weather perils, including but not limited to hurricanes, tornadoes and floods) as well as weather considerations set forth in the Directions, application in any manner not explicitly set forth in the Directions, moisture conditions outside the moisture range specified in the Directions, or the presence of products other than those set forth in the Directions in or on the soil or crop.

THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF THE LIABILITY OF THIS COMPANY OR ANY OTHER SELLER FOR ANY AND ALL LOSSES, INJURIES OR DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT (INCLUDING CLAIMS BASED IN CONTRACT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT OR OTHERWISE) SHALL BE THE PURCHASE PRICE PAID BY THE USER OR BUYER FOR THE QUANTITY OF THIS PRODUCT INVOLVED, OR, AT THE ELECTION OF THIS COMPANY OR ANY OTHER SELLER, THE REPLACEMENT OF SUCH QUANTITY OR, IF NOT ACQUIRED BY PURCHASE, REPLACEMENT OF SUCH QUANTITY. IN NO EVENT SHALL THIS COMPANY OR ANY OTHER SELLER BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.

The buyer and all users are deemed to have accepted the terms of this LIMIT OF WARRANTY AND LIABILITY which may not be varied by any verbal or written agreement.

2. GENERAL INFORMATION

This product is recommended for preemergence control of most annual grasses and certain broadleaf weeds. It should be applied to the soil surface prior to crop or weed emergence. The soil surface should be freshly worked and free of weed growth. The seed bed should be fine, firm and free of clods and trash. Better results are obtained when moisture occurs within one week after application. High intensity or excessive rainfall, or excessive irrigation, after application may reduce control.

Use of this product not consistent with this label may result in injury to persons, animals or crops, or other unintended consequences. Keep bag closed to prevent spills and contamination.

Do not reuse empty container. Destroy it by burying with waste or burning. Stay away from smoke.

3. APPLICATION EQUIPMENT AND CALIBRATION

Broadcast Treatment—Use broadcast applicators that can apply these granules evenly.

Band Treatment (Behind Press Wheel only)—Use applicators designed for this purpose. Calculate the amount of granules per acre needed for band treatment as follows:

$$\frac{\text{Band width in inches}}{\text{Row width in inches}} \times \text{Broadcast Rate per acre} = \text{Band Rate per acre}$$

For example: If 26 pounds per acre are recommended for broadcast treatment and you wish to treat a band of 14 inches wide in crop rows spaced 38 inches apart:

$\frac{14}{38} \times 26 =$ 9.6 pounds of granules needed for the band treatment

NOTE: For application of this product do not rely on settings used for other granular herbicides.

Calibration—The following settings are only guidelines for calibration; they do not allow for equipment variation or wear. Check settings after initial calibration so that the proper rate is applied.

	GRANULAR APPLICATOR SETTING			
	Broadcast Rate Per Acre			
	16 pounds		20 pounds	
APPLICATOR	4 mph	5 mph	4 mph	5 mph
Allis-Chalmers	3	3	4	4
Gandy	12.9	14.5	14.4	16.3
International Harvester	1/7.2	1/8.9	1/8.9	2/1.5
John Deere	1/25	1/28	1/28	2/3
Noble*	10	14	14	17

	GRANULAR APPLICATOR SETTING			
	Broadcast Rate Per Acre			
	23 pounds		26 pounds	
APPLICATOR	4 mph	5 mph	4 mph	5 mph
Allis-Chalmers	4	4	5	5
Gandy	15.6	17.5	16.6	18.7
International Harvester	2/0.3	2/3.8	2/2.1	2/6.0
John Deere	2/1	2/5	2/3	2/8
Noble*	16	18	17	20

*The Noble applicator settings listed above are for the model made prior to 1973.

It is important that the applicator be calibrated properly to deliver the desired amount of this product. To calibrate, set the applicator and attach a bag over the spreader plate or remove the delivery tube and attach a plastic nursing bottle over the spout. Operate at a constant speed on terrain to be planted. Four to 5 mph is suggested. For a 14-inch band, collect the granules for 500 linear feet (583 sq. ft. area) and measure the VOLUME or WEIGHT collected. Tap plastic nursing bottle or other measuring container gently to settle the granules when taking a reading.

Refer to the following table to determine the broadcast rate per acre for the amount collected. If necessary adjust the application equipment so that each spout dispenses the proper amount.

Broadcast Rate Per Acre	Volume Collected in 500 linear feet for a 14 inch band	Weight Collected in 500 linear feet for a 14 inch band
16 lb	4.4 fl oz	3.4 oz
20 lb	5.6 fl oz	4.3 oz
23 lb	6.4 fl oz	4.9 oz
26 lb	7.2 fl oz	5.6 oz

For other band widths calculate the calibration distance as follows:

$$\frac{\text{14 inches}}{\text{Band width in inches}} \times 500 = \text{Calibration distance in linear feet.}$$

4. WEED CONTROL

When applied as directed this product WILL CONTROL the following weeds:

ANNUAL GRASSES

Barnyardgrass
Echinochloa crusgalli
Crabgrass
Digitaria spp.
Fall Panicum
Panicum dichotomiflorum
Giant Foxtail
Setaria faberii
Goosegrass
Eleusine indica
Green Foxtail
Setaria viridis
Yellow Foxtail
Setaria glauca

ANNUAL BROADLEAVES

Carpetweed
Mollugo verticillata
Florida Pusley
Richardia scabra
Pigweed (Carelessweed)
Amaranthus spp.
Purslane
Portulaca oleracea

When applied immediately after planting, this product at a rate of 16 to 26 pounds per acre on broadcast basis will reduce competition from the following HARD TO CONTROL weeds:

SEDGES

Yellow Nutsedge
Cyperus esculentus

ANNUAL BROADLEAVES

Lambsquarters
Chenopodium album
Common Ragweed
Ambrosia artemisiifolia
Teaweed (Spiny Sida)
Sida spinosa

This product WILL NOT CONTROL Rhizome Bermudagrass, Field Bindweed, Bull Nettle, Canada Thistle, Rhizome Johnsongrass, Morningglory and Quackgrass.

5. CULTIVATION INFORMATION

If grass or weed seedlings emerge before it rains rotary hoeing will improve performance.

If cultivation is necessary because of soil crusting or compaction, tillage should be shallow to minimize dilution of this herbicide.

Except for the above, as long as the grasses and weeds are controlled, delay cultivation as long as possible.

Only after weeds emerge in the treated band, set cultivator to throw soil into the row covering the band. On peanuts, do not throw soil into the row.

6. DIRECTIONS FOR USE

FIELD CORN, HYBRID SEED CORN, SILAGE CORN AND SOYBEANS

For control of listed annual grasses and broadleaf weeds apply after planting and before crop or weeds emerge. For band treatment apply granules behind the press wheel. See table below for recommended rates on various soil textures.

	BROADCAST RATE PER ACRE	
SOIL TEXTURE	Less than 3% organic matter	More than 3% organic matter
MEDIUM		
Loams	16 lb	20 lb
HEAVY		
Silty Clay Loam thru Clay	20 lb	26 lb

For Lister or Deep Furrow Planted Corn

Broadcast Treatment—Apply at the rate of 16 pounds per acre.

Band Treatment (Behind Press Wheel)—For a 10 inch band treatment over the row (40 inch spacing) apply 4 pounds per acre. For a 7 inch band treatment over the row (40 inch spacing), apply 2.8 pounds per acre.

If heavy rains follow application, weed control on the top and sides of the furrow may not be as good as that obtained in the bottom of the furrow.

Where deep lister planting is practiced, only partial weed control can be expected on steep furrow sides. It is suggested that a 7 inch band be applied at the bottom of the furrow. Better results can be expected where the granules lie on an even flat surface which is not subject to shifting by wind or rain.

For Furrow Irrigated Corn and Soybeans

This product must be incorporated into the soil by harrow, finger weeder or rotary hoe. Shallow incorporation of at least ½ inch but not more than 2 inches is most effective for weed control. Incorporation deeper than 2 inches may result in unsatisfactory weed control. Incorporation depth must be kept above the seed. Soil moisture at application must be sufficient for crop and weed emergence. Irrigation within 10 days following planting may improve weed control. See the table above for recommended rates.

PEANUTS

Broadcast—Apply 20 pounds of this product per acre from immediately after planting and until either crop or weeds emerge. NOTE: Hard to control weeds require 23 to 26 pounds per acre.

843.77-000.07 (EPA Reg. No. 524-296-AA)

Lasso II...versatile granular herbicide for corn, soybeans and peanuts

1. Granular Lasso II herbicide controls many weeds with good crop tolerance on your soybeans, corn or peanuts when used as directed and at the recommended rates. Lasso II controls many annual grasses and certain broadleaf weeds.
2. Lasso II is versatile . . . it lets you plant the way you want to plant, when you want to plant:
    - Banding.
    - Surface apply with a planter.
    - Apply *one* herbicide to *three* crops . . . corn, soybeans and peanuts.
    - Allows crop rotation (no carryover).
3. Lasso II works well in a wide range of soil textures.
4. Lasso II also works well under a wide range of moisture conditions.
5. Granular Lasso II breaks down and allows you to rotate crops without risk of carryover damage. You can follow your corn, soybean or peanuts treated with Lasso II with vegetables, sugarbeets, small grains or other profitable crops.
6. Granular Lasso II fits your herbicide program . . . you don't have to design your program around Lasso II

The label for Lasso II:

For proper usage . . . and to receive the full benefits of this product, always read the label and follow the label directions carefully.

Monsanto

Monsanto Agricultural
Products Company
St. Louis, Mo. 63166

a unit of Monsanto Company

S-1/79-216

Private Pesticide Applicator Label Worksheet

1. Lasso II
2. None (Lasso)
3. Herbicide
4. Alachlor - 15%   Inert ingredients - 85%
5. 15% Alachlor
6. Monsanto Company
7. CAUTION is the signal word
8. Irritating to eyes. May cause allergic skin reaction.
9. Page 1. EPA Reg. NO 524-296-AA
10. The establishment number tells what factory made the chemical. This number does not have to be on the label, but will be somewhere on each container.
11. Page 1. Corn, Soybeans and Peanuts
12. Page 1. It should be applied to the soil surface prior to crop or weed emergence. The soil surface should be freshly worked and free of weed growth. Better results are obtained when moisture occurs within one week after application.
13. Most annual grasses and certain broadleaf weeds. See #4 WEED CONTROL for specific species of weeds.
14. Use of this product not consistent with this label may result in injury to persons, animals, or crops.
15. The recommended rate is between 16 and 26 pounds per acre on a broadcast basis. The band rate of application is dependent upon band width.
16. This herbicide is not classified as restrictive use.
17. Eye Protection, Skin Protection, Respiratory Protection
18. In case of contact, flush skin or eyes with plenty of water. Wash thoroughly after handling. Launder clothing before reuse.
19. Call the Monsanto Company at 314-694-1000 or Department of Natural Resources Hotline at 1-800-532-1114.
20. Keep bag closed to prevent spills and contamination.
21. Do not reuse empty container. Since this is a granular pesticide that is packaged in a bag, destroy it by burning.

As a farmer or as a consumer, you know how important it is to control pests. Without pesticides, one-third of all the crops—in fields, orchards, and forests—would be lost to pests in the United States. But pest control can be improved in terms of energy, the environment, and economics.

While more food is being produced at less cost, more pests are becoming resistant and expensive to control. Pesticides that cost $4 per acre 10 years ago now cost over $20 per acre—that's a 400 percent increase, and the cost of applying the pesticides is going up as well.

To keep farm production profitable, you need to control pests as cheaply and efficiently as possible. Integrated pest management (IPM) will help. IPM is a program that emphasizes pest prevention whenever possible. You can limit your chances of a pest outbreak by timing of tillage, selecting resistant crops, using pesticides judiciously, and other pest management practices. Following integrated pest management, you act to control pests only when it pays to do so.

IPM consists of four major strategies working together to manage insects, diseases, nematodes, and weeds:
- crop management and cultural practices
- field scouting
- economic threshold
- chemical and biological control

Grassho[illegible] occasional pest of corn.

Crop Management and Cultural Practices

Crop management and cultural practices disrupt the pests' environment. These methods include selecting resistant crop varieties, timing of planting and harvesting, tillage practices, water and fertilizer management, and crop rotation.

Field Scouting

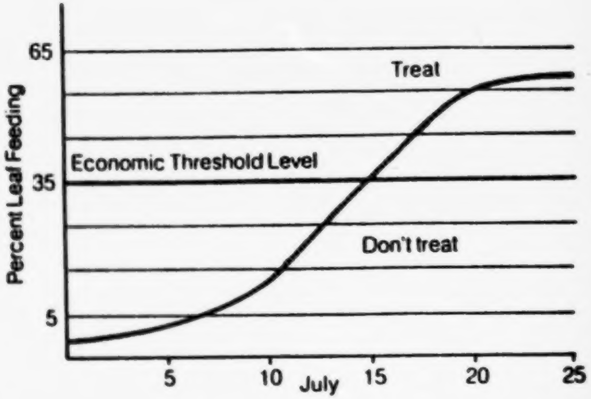
Field scouting is monitoring and detecting pests. Scouting the fields is the only way for you to predict if you must use pest control methods. For example, rootworm beetle scouting in August will tell you if a corn rootworm insecticide will be needed the next year. If not, you could save $5 to $8 per acre. You can either scout the fields yourself or hire a scout to do it for you. Either way, your County Extension Director can help.

Scouting the fields will tell you if you need to control pests.

Economic Threshold

Scouting helps predict when to control pests based on the economic threshold, which is simply the number of pests that can be tolerated before you must control them. In other words, if the pests aren't there, or at high enough levels, don't try to kill them. For example, if less than 35 percent of your corn shows whorl or leaf feeding from European corn borers, you will not need to apply a treatment because crop losses will be less than the cost of control (see chart).

Economic Threshold European Corn Borer



But at the 35 percent threshold, your treatment will be justified because the benefits of a treatment will exceed the cost of control. Knowing when to treat your fields not only will save you time, it will save you money and energy as well.

Chemical and Biological Control

Chemical control means applying pesticides when needed. In an IPM program, pesticides aren't applied until pests reach the economic threshold.

Biological control involves regulating pests by their natural enemies. This can be a valuable pest management tool since all fields contain some naturally occurring parasites. Biological control works best on non-rotated crops like alfalfa and orchards; it is not as effective on rotated crops like corn and soybeans. Weather also limits the success of biological control.

Lady bug larvae feeding on aphids is one method of biological control.

Sometimes integrated pest management is confused with biological control. Although there are times when pesticides are not necessary, the purpose of IPM is not to replace pesticides with biological control, but rather to use them judiciously with your other methods of pest management.

Integrated pest management is a risk-reducing program—it takes the guesswork out of managing pests, saving you time, money, and energy. IPM is environmentally and economically sound agriculture based on good cultural and crop management practices. Any time you control pests based on need, you are reducing the environmental impact of pesticides and are often saving money.

Let your Cooperative Extension Service help you produce better crops at lower costs. Contact your County Extension Director concerning IPM programs in your county.

Prepared by [illegible] hry, extension editorial assistant, and Jerry DeWitt, coord[illegible] egrated pest management.

File: Agronomy 11-IPM

Cooperative Extension Service, Iowa State University of Science and Technology and the United States Department of Agriculture cooperating. Charles E. Donhowe, director, Ames, Iowa. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914.

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ISU P69 [illegible]

integrated
IPM pest
management

what is it?

Cooperative Extension Service
ES Iowa State University
A[illegible]owa 50011

[illegible] June 1980

ACT-PEST-3

INTEGRATED PEST MANAGEMENT

Use INFO-PEST-2 in answering the following questions:

1. What is integrated pesticide management (IPM)?

2. How do farmers and consumers benefit by the implementation of an IPM system?

3. How can cultural practices and crop management reduce the need for pesticides to produce bountiful crops? What do these practices include?

4. How can field scouting be used to reduce the need for pesticides?

5. What is an economic threshold?

KEY-ACT-PEST-3

INTEGRATED PEST MANAGEMENT

(Answers to ACT-PEST-3)

1. ANSWER: Integrated pest management consists of four major strategies working together to manage insects, diseases, nematodes, and weeds:
    1. crop management and cultural practices,
    2. field scouting,
    3. economic threshold, and
    4. chemical and biological control
2. ANSWER: Farmers benefit from reduced energy and input costs while consumers enjoy safer food products and an environment with less potential pesticide hazards.
3. ANSWER: Crop management and cultural practices disrupt the pests' environment. These methods include selecting resistant crop varieties, timing of planting and harvesting, tillage practices, water and fertilizer management and crop rotation.
4. ANSWER: Scouting the fields is the only way for an operator to predict if pest control measures are needed.
5. ANSWER: An economic threshold is simply the number of pests that can be tolerated before it pays to control them. (Below the economic threshold, pesticides cost more than the loss from pest damage.)

NOTE: For an additional reference see page 20 of the Journal of Fresh Water for an article entitled: IPM: A Broad Perspective; A Systems Approach".

IPM DECISION MAKING

Decision making to determine whether or not pest control is needed is the bottom line of an IPM program. The three components of IPM (crop/pest biology, monitoring, and economic threshold) provide the needed information. Using this information, the IPM decision making process involves the following questions and steps:

1. Is control needed? Answers are based on whether or not monitoring shows pest levels above threshold, predictive programs indicate potential problems, and crop is in a susceptible growth stage.

2. Are non-chemical control methods available? Crop/pest biology information indicates what non-chemical control methods are available. If available and effective, their use is recommended.

3. If pesticide application is the only method available, is there a choice of material available? If several materials have equivalent efficiency, then selection is based on potential environmental impact.

4. Once a pesticide is selected, the label is checked for application rate, time, and method. Use must be according to label directions.

5. Can materials be mixed or adjuvant added to improve efficiency or reduce chances of resistance?

6. Pesticide is applied at the time that maximizes effectiveness and reduces need for subsequent application.

OTHER IMPORTANT CONSIDERATIONS FOR IPM

1. How many of the above steps help reduce energy costs?

2. What procedures would be included in IPM if a fourth informational component emphasizing groundwater pollution potential was added?

Source: Adapted from "Agricultural Management Practices to Minimize Groundwater Contamination" -- University of Wisconsin Extension Service.

IPM DECISION MAKING

1. If control is not needed, energy savings will be realized by less trips over the field and less pesticides used (most pesticides are petroleum based products).

2. Crop rotation can be a long term method of control that can result in reduced weed and pest problems. Crop rotation can effectively reduce energy costs and distribute labor.

3. Always choose the chemical that has the lowest environmental impact and the lowest energy costs.

4. Label directions can help reduce costs by ensuring proper application of the pesticide.

5. Mixing compatible chemicals can reduce the number of trips over a field. The reduction of passes over a field can result in less compaction and energy costs.

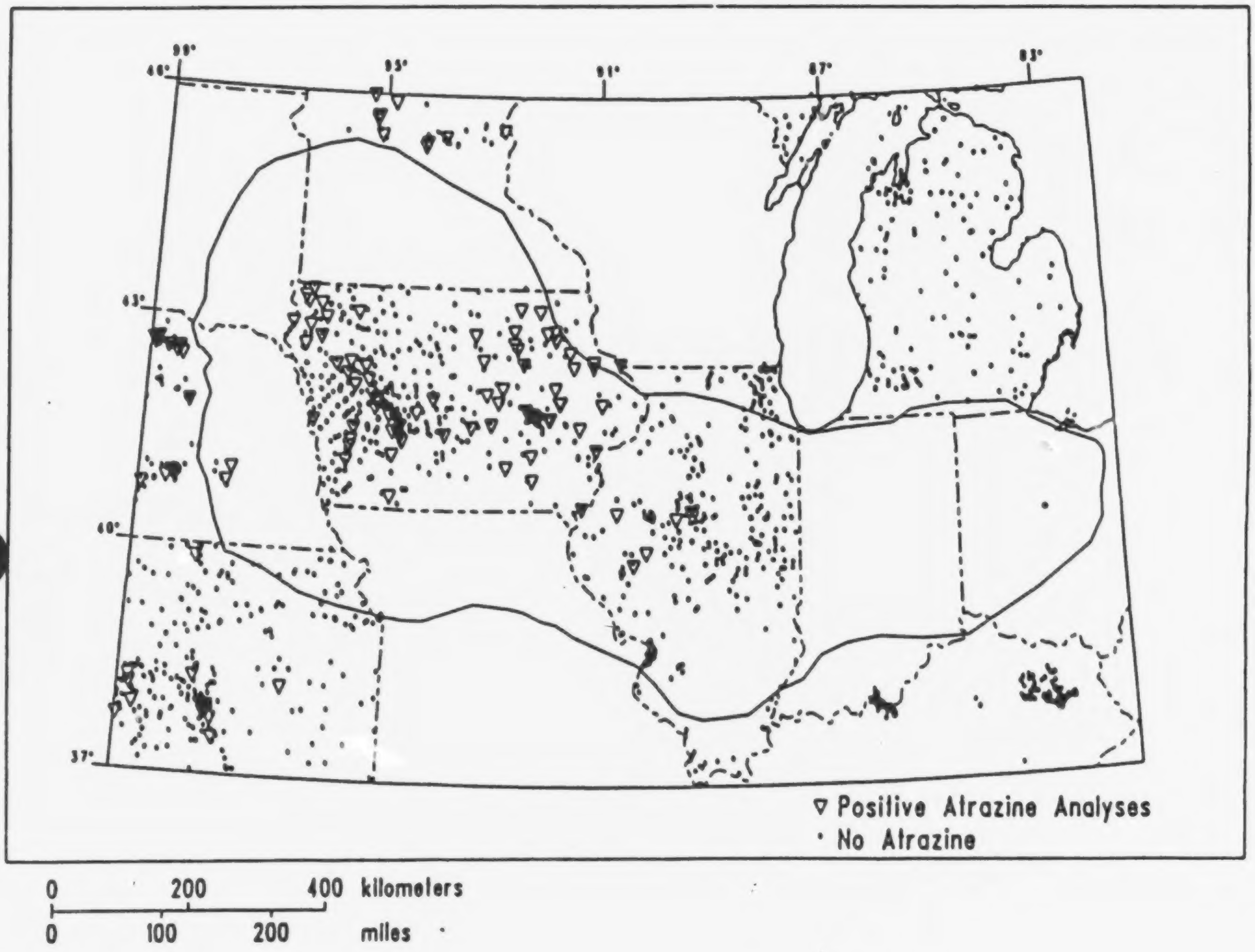
6. Timely application of pesticides reduces the need for subsequent applications, thereby reducing unnecessary trips over a field. This management technique saves energy and reduces compaction problems.

OTHER IMPORTANT CONSIDERATIONS FOR IPM ARE:

1. All steps help reduce energy costs

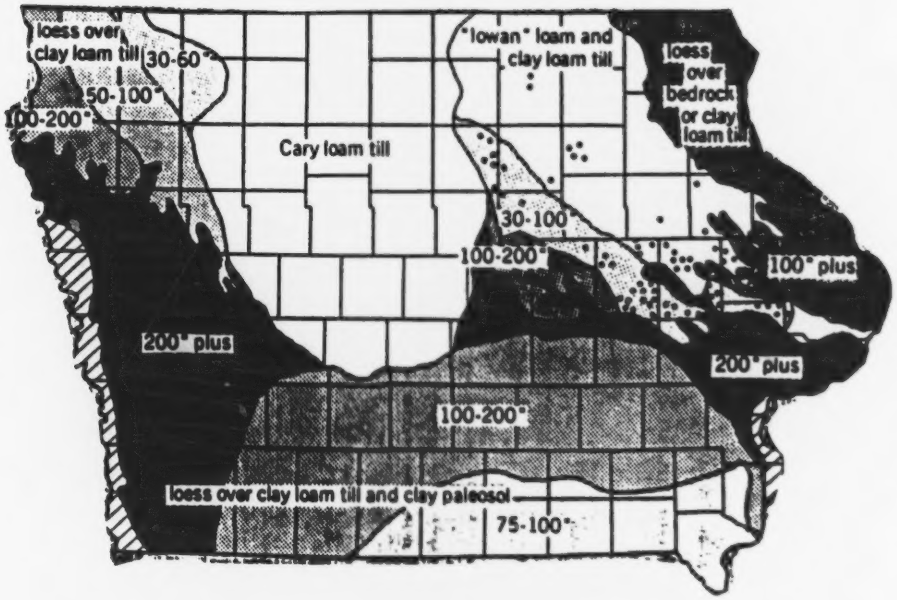
2. The value of IPM as a groundwater protection practice could be enhanced by the development of a fourth information component (in addition to crop/pest biology, monitoring, and economic threshold) emphasizing groundwater pollution potential. This component would include procedures for evaluating the soils, geology and water movement characteristics of a site to determine leaching potential. This information coupled with information on what pesticides, if any, have leached to groundwater under similar conditions could be supplied to producers for consideration when they develop their pest control strategy.

DISTRIBUTION OF ATRAZINE IN WELLS


99°
95°
91°
87°
83°
46°
43°
40°
37°
▽ Positive Atrazine Analyses
· No Atrazine
0
200
400 kilometers
0
100
200
miles

Source: U.S. Geological Survey

SOIL SURFACE MATERIALS IN IOWA


loess over clay loam till
30-60"
50-100"
100-200"
Cary loam till
"Iowan" loam and clay loam till
loess over bedrock or clay loam till
30-100"
100-200"
100" plus
200" plus
200" plus
100-200"
loess over clay loam till and clay paleosol
75-100"

Source: Principle Soils of Iowa, Iowa State University

ACT-PEST-5

PESTICIDES IN DRINKING WATER

Using the pesticides in drinking water handout, answer the following questions.

1. How do pesticides get into water supplies?

2. What are patterns of pesticide contamination?

3. What health risks are involved in pesticide contamination of groundwater?

4. How can pesticide levels be reduced?

INFO-PEST-3

PESTICIDES IN DRINKING WATER

Pesticides not taken up by plants, adsorbed by soils or broken down by sunlight, soil organisms or chemical reactions may ultimately reach groundwater sources of drinking water. Although this amount is very small, it will depend upon the nature of the soil, depth of the groundwater, chemical properties of the pesticide, and the amount and timing of precipitation or irrigation in the area. Usually the faster a pesticide moves through the ground, as with sandy soils and heavy rainfall or irrigation, the less filtration or breakdown. Heavier soils, combined with lower moisture levels and warmer temperatures, provide a greater opportunity for pesticides to break down before reaching groundwater. Once in groundwater, pesticides continue to breakdown, but usually much slower than in surface layers of soil.

Generally, pesticides are a problem with private rather than community wells because private wells are shallower and often located near areas of pesticide use. This means that some pesticides' toxic qualities may still be present when the water is drawn for human use.

Analysis of public water supplies examined by EPA, through one-time monitoring required by House File 2303 in 1987, indicated that a total of nine different pesticides were found in water of 62 water supplies. Metochlor (Dual) showed maximum concentration of 29 ppb. Atrazine was the most prevalent pesticide present in about one-half of the public water supplies where pesticides were detected. These two chemicals were the most prevalent pesticides found in raw water samples analyzed by the U.S. Geological Survey during 1985-1987.

Pesticides can be absorbed through the skin and lungs as well as by drinking water. Adverse health effects are unknown from consuming water with pesticides below the health advisory levels. Potential health effects in people consuming pesticides above the health advisory levels depend upon the kind and amount of pesticide, how long the person has been consuming the water, and the person's overall health. Acute pesticide poisoning symptoms may include headaches, dizziness, stomach and intestinal upset, numbness of extremities, spasms, convulsions, and heart attacks. These symptoms would be considered chronic if they persist over a long period of time, but ultimately lead to death.

While the long-term effects of pesticides in humans are not completely understood, some pesticides are suspected of causing cancer. Additionally, the well sampling program must consider possible additive effects when more than one pesticide is present.

Removing pesticides from groundwater is not only difficult, but very costly and sometimes impossible. To avoid further pesticide contamination, informed and careful pest control is necessary. Pesticides should not be viewed as the only answer to a pest problem; other methods may be appropriate. Integrated Pest Management (IPM) may include crop rotation, biological control, and soil analysis and conditioning. Follow label instructions exactly when using pesticides. This includes instructions for storage and handling, and disposal of empty containers. Besides careful pesticide management, decreasing entry sites (plugging) of groundwater pollutants can decrease pesticide contamination of wells.

Demonstrating careful pesticide use for all people and spreading awareness of pesticide concerns to neighbors will also help safeguard our groundwater.

Federal and state efforts will continue to provide better storage and handling guidance, assure proper label instructions, and increase knowledge of factors such as well depth and location if groundwater is contaminated by a pesticide. We live in a society accustomed to quick repair of damaged goods, but our air, soil, and water cannot be replaced. Remedying the problem of pesticides in water supplies requires public concern for natural resources and for those who must use them in years to come.

Source: Adapted from "Pesticides in Drinking Water", Wisconsin Department of Natural Resources

KEY-ACT-PEST-5

PESTICIDES IN DRINKING WATER

1. How do pesticides get into well water supplies?

   ANSWER: Through soil or direct paths to groundwater such as spills around a poorly sealed well, back-siphonage during spray tank filling, improper disposal of pesticide containers. Research shows the most common source is through soil in field application.

2. What are patterns of pesticide contamination?

   ANSWER: Generally pesticide pollution is more apt to be found in private wells than community wells because private wells are shallower and often located near areas of pesticide use.

3. What health risks are involved in pesticide contamination of groundwater?

   ANSWER: The long-term effects of pesticides in humans are not completely understood. Acute and chronic health effects are the two basic types of toxicity to people.

4. How can pesticide levels in groundwater be reduced?

   ANSWER: Use an integrated pest management program, use pesticides only if needed, and consider biological or cultural practices such as crop rotations.

BEST MANAGEMENT PRACTICES

ROTATION

Rotation has long been recognized as an effective cultural practice. Rotations are most effective for control of pests that have specific host requirements and do not have the ability to go dormant for a long period of time. Advantages of a crop rotation system include: Greater distribution of labor, improved soil tilth, decreased soil erosion, plant-produced nitrogen, and distribution of income throughout the year. Pests that are difficult to control with rotation because they can survive long rotations, include wireworm, velvetleaf, and soybean cyst nematode.

INCORPORATION

Surface incorporation of chemicals can result in increased efficiency of the chemical as well as reduced surface runoff and surface water contamination. This is especially true for chemicals with moderate soil adsorption characteristics. For chemicals with a high attraction for soil, erosion must be controlled to prevent transport of chemicals off-site. Groundwater benefits may be achieved with reduction of chemical use through more specific placement techniques such as ridges, where infiltration is lower. Pesticide application rates may be reduced by utilizing these methods. Input costs per acre can be reduced by utilizing this procedure.

MECHANICAL WEED CONTROL

Herbicide use can be minimized by using mechanical weed control in association with banding chemical application methods. This can provide improved infiltration characteristics in the inter-row zone which can help minimize leaching in the treated row zone. Mechanical weed control is an economically viable alternative to chemical control for most producers if they have an adequate cultivator and a labor supply.

VARIOUS PLANT POPULATIONS

More equal spacing and high plant stands may produce a very slight increase in water infiltration (nitrate leaching and pesticide movement), but could reduce herbicide needs, where cultivation is still possible, due to greater crop shading of weeds. Higher plant populations and narrow rows cause the crop canopy to close earlier, competing better with weeds.

TILLAGE PRACTICES

Tillage systems that leave a rough porous surface, protected with a mulch of plant residue, will have more infiltration and less runoff than systems that leave a relatively smooth and clean surface. The former, referred to as conservation tillage systems, will provide more plant available water in the soil profile as well as added opportunities for movement of solutes downward toward the groundwater. This would be an especially important consideration in moderate to very permeable soils. This practice reduces the number of trips over a field, thereby reducing soil compaction and the input costs of a crop.

Conservation tillage is effective in reducing erosion and improving surface water quality, but under certain conditions, an increase in potential groundwater contamination might be expected. Present research is attempting to provide more answers. Early indication of some research indicates less potential for groundwater contamination with conservation tillage compared to conventional tillage. More research is needed to provide answers on how to adapt the various kinds of conservation tillage to a groundwater quality program.

GRASS FILTER STRIPS

Grass filter strips along field edges can trap pesticides to prevent surface water contamination. Similar strips around sinkholes or agricultural drainage well surface inlets can reduce contamination of groundwater. In a Pennsylvania study, grass filter strips reduced atrazine runoff by 90% during intense, 100-year frequency storm (Hall et al., 1983). Filter strips can also serve to reduce erosion and compaction of equipment to and from a field. This land may be eligible as set-aside acreage or conservation reserve.

Source: Adapted from: Best Management Practices to Improve Groundwater Quality in Iowa, Iowa State University, Cooperative Extension Service

RIDGE TILL-PLANTING TO REDUCE CHEMICAL USE and SAVE ENERGY

Using the diagram (ACT-PEST-6B), direct students to list the reasons ridge till planting could reduce pesticide use and conserve energy.

KEY POINTS THAT SHOULD BE EMPHASIZED ARE:

1. Only two tillage operations are necessary.

2. Less machinery is needed - no plow, no disk, no harrow, no rotary hoe, no chisel, no field cultivator, no spring tooth harrow - just a planter, a cultivator, and stalk chopper.

3. With banding over broadcast application, savings in chemicals applied is at least 50%; the fuel bills are lower and energy is saved. American farmers together could save 150,000 barrels of oil per day, almost 50 million barrels per year.

4. Weed control is easier in the long run; weed seeds are pushed to space between rows where cultivator can take them out.

5. Reduced erosion means less movement of pesticide which is attached to soil particles or water.

Source: Adapted from: "More Profit with Less Tillage" by Ernest E. Behn (pg. 27-28). Wallace-Homestead Book Company. 1982.

GROUNDWATER QUALITY AND ENERGY CONSERVATION RIDGE-TILL, BANDING AND INCORPORATING

Key:

δ = Rain

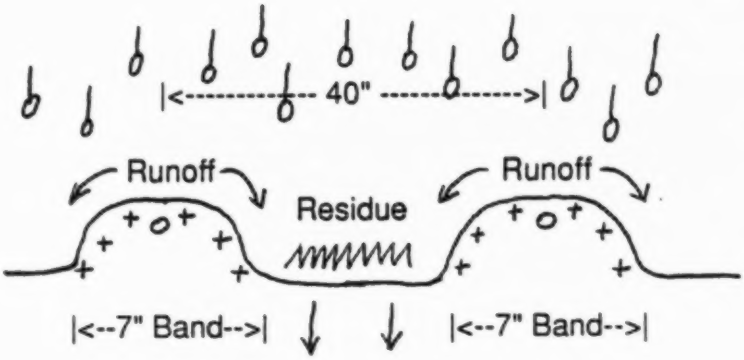
o = Seed

+ = Pesticide

↓ = Water Movement

Field A – Ridge Till

Banding - incorporation
------------>

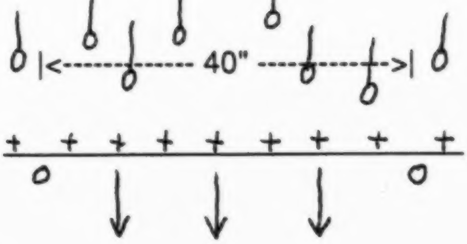


Advantages

- less insecticide - less energy used
- less leaching of pesticide
- less erosion if contoured

FIELD B -- Conventional Till

Broadcast
on ------->
Surface



Disadvantages

- more insecticide - more energy used
- more leaching of pesticide
- more erosion if on sloping land

PESTICIDE CHARACTERISTICS AND SELECTION

Some pesticide properties have an obvious effect on water quality while others are more subtle. When estimating site-specific water quality risks, the effect of pesticide properties must be considered in relation to that site's characteristics. Charactertistics to be considered include soil type, slope, depth and surface water. If lower-risk pesticide options are not available, the user should be advised to consider alternatives such as tillage for weed control or crop rotations to reduce pests.

The following pesticide characteristics need to be analyzed in selecting the lowest risk pesticide for a given site and purpose.

SOLUBILITY IN WATER

The solubility of the pesticides in water at room temperature is given in ppm (mg/l). This is the solubility of the pure active ingredient, not the formulated product. Solubility is a fundamental physical property of a chemical and will strongly affect the ease of wash off and leaching through the soil. In general, pesticides with solubilities of 1 ppm or less will tend to stay at the soil surface and be washed off the field in the sediment phase runoff. Thus practices designed to reduce erosion will also stop pesticide runoff.

HALF-LIFE IN SOIL

Half-life, given in days, is the time required for pesticides in soils to be degraded so that their concentration decreases by one-half. Pesticide degradation can be accurately described by assuming that each successive elapsed half-life will decrease the pesticide concentration by half, so for example, a period of two half-lives will reduce a soil concentration to one-fourth of the initial amount. "Persistence times" often reported in the literature are the times required for a pesticide to degrade to the point that it is no longer active. We have arbitrarily assumed this equal to four half-lives when a persistence time was the only data available.

SOIL SORPTION INDEX

The index for soil sorption is measured by the Koc value. The Koc measures the tendency of the pesticide to be strongly attached, by chemical or physical bonds, to soil particle surfaces. The higher Koc values (1000) have a stronger attachment to soil and a lesser tendency for the pesticide to move except with sediment movement. Conversely, the lower Koc values will tend to move with the water and have a potential for deep percolation below the root zone or being carried in runoff water.

RUNOFF POTENTIAL

The runoff potential indicates the tendency of the pesticide to move with sediment in runoff. A large rating means the pesticide has a high tendency to move with sediment while a small rating means the pesticide has a low potential to move with sediment.

LEACHING POTENTIAL

The leaching potential indicates the tendency of a pesticide to move in solution with water and leach below the root zone into deep percolation. The ratings of large, medium, small, and total use describes the potential for leaching. A rating of large means the chemical has a high potential for leaching. The total use rating means the pesticide should not leach with the percolating water.

Source: Adapted from SCS Water Quality Workshop Integrating Water Quality and Quantity Into Conservation Planning; 1988

PESTICIDE SELECTION EXERCISE

PESTICIDE DESCRIPTION

Pesticide A - Very high solubility in water, low sorption index

Pesticide B - Low solubility and a high soil sorption index

QUESTIONS TO CONSIDER

1. Which pesticide would you select for a field with little erosion positioned over a high water table which contains relatively shallow wells?

2. Which pesticide would you select for a field on moderate sloping land, with erosion potential? Additional information: The field is situated in the watershed of a municipal surface water supply pond, from which the community obtains their drinking water?

ACTIVITY: Read the label of some selected common pesticides and determine which would be the least water quality risk for a field on your farm or a selected farm. (Refer to your county soil survey report for soil and water table characteristics.)

Demonstration: Illustrate pesticide leaching and adsorption characteristics (Reference: Soil Type) using the grape juice demonstration on the Groundwater Flow Model or video.

ANSWERS:

1. Pesticide B with a low leaching potential
2. Pesticide A with a low runoff potential

ACT-PEST-8

COMPARING BROADCASTING AND BANDING OF PESTICIDES

INSTRUCTIONS: Use the following problem to illustrate how to calculate the savings from banding versus broadcasting pesticides.

When the broadcast rate is given in pesticide instructions, determine the band rate as follows:

$$\frac{\text{Width of band (inches)}}{\text{Row spacing (inches)}} \text{ X } \begin{matrix}\text{broadcast rate in} \\ \text{gal./ac or lb./ac}\end{matrix} = \begin{matrix}\text{Gal./ac. of spray} \\ \text{lb./ac of granules} \\ \text{for band}\end{matrix}$$

For example, if you want to spray a 7-inch band on a 40-inch row spacing, the broadcast rate is 10 gallons per acre. The band rate you would use is 1 3/4 gallons per acre.

7/40 x 10 = 1 3/4 gallons per acre

PROBLEM:

You are considering banding all your pesticides and liquid fertilizers in the next cropping season. The broadcast rate of the pesticide you use on your corn acreage is 12 gal./acre. If you want to spray a 9-inch band on a 36-inch row spacing, what is the band rate?

ANSWER: 9/36 x 12 = 3 gallons per acre

The corn pesticide costs $8 per quart. If the manufacturer of the pesticide recommends 1 quart of actual product per acre using a broadcast application, how much does banding reduce the pesticide costs per acre? REMEMBER: 12 gal. per acre were sprayed using the broadcast method.

ANSWER: 3 gal./ 12 gal. = ($?) / $8
.25 = ($?) / $8
$8 x .25 = $2

$8 - $2 = **$6 SAVINGS PER ACRE**

What are the environmental and energy implications?

BROADCAST SPRAYER CALIBRATION

Careful sprayer calibration will prevent you from using too much or too little herbicide. A sprayer should be calibrated at the beginning of the season and any time you change application rates or make a change in the spray delivery system, such as a nozzle or pump change. Periodic checks are needed also, because the normal wearing of the nozzles and other sprayer parts may change the flow rate.

Data from sprayer operating manuals will give you a starting point for calibrating your sprayer, but may not be accurate enough for fine tuning the sprayer under your conditions. For this, a calibration test is needed, where you apply a measured amount of liquid on a known area under actual field conditions.

Prior to conducting the following calibration procedure outlined in INFO-PEST-6, proceed with the following steps:

1. Be sure to rinse the tank first to clean out material last used.

2. Add water to the tank until it is approximately half full.

3. Check the nozzles for uniformity.

   Catch and record the number of ounces sprayed by each nozzle in 15 seconds. Calculate the average output of all nozzles. Replace any nozzle whose output differs more than 5 percent from the average of all nozzles on the boom.

4. Continue with procedures outlined in Extension Guide #Pm-817a

NOTE: Pressure on sprayer should be between 35 and 50 psi.

To increase or decrease gallons of spray delivered per acre, change the nozzle size, vary speed, adjust pressure within the 35 to 50 psi range at the nozzle and recalibrate.

Source: Adapted from "Fundamentals of No-Till Farming" - AAVIM

Broadcast Sprayer Calibration

To Calibrate:

Materials needed: measuring tape, watch with a second hand, and measuring jar graduated in ounces.

1. Fill sprayer tank with water.

2. Determine nozzle spacing in inches and measure appropriate distance in the field according to the following table:

Nozzle spacing (inches)	Travel distance (feet)
20	204
30	136
36	113
38	107
40	102

3. In the field, drive the designated distance at your normal spraying speed. Record travel time in seconds.

4. Set the desired pressure on sprayer. With the sprayer parked, collect the output from each nozzle for the recorded travel time. Record the output of each nozzle separately.

5. Calculate the average discharge rate of all nozzles in ounces.

   Ounces = Gallons per acre

   If the above gallonage is not reasonable for the product being applied, change the rate by:

   —Adjusting the pressure, or

   —Adjusting the travel speed, or

   —Changing nozzle size

   and recalibrate.

6. If any nozzles are more than 5% below or above the average discharge rate and nozzles are new, replace those tips and recalibrate. If nozzles are old, replace all tips and recalibrate.

File Ag Chemical Safety

Cooperative Extension Service
Iowa State University
Ames, Iowa 50011

Pm-817a | Reprinted | March 1986

An adhesive label for attaching to sprayer equipment is available as Pm-817.

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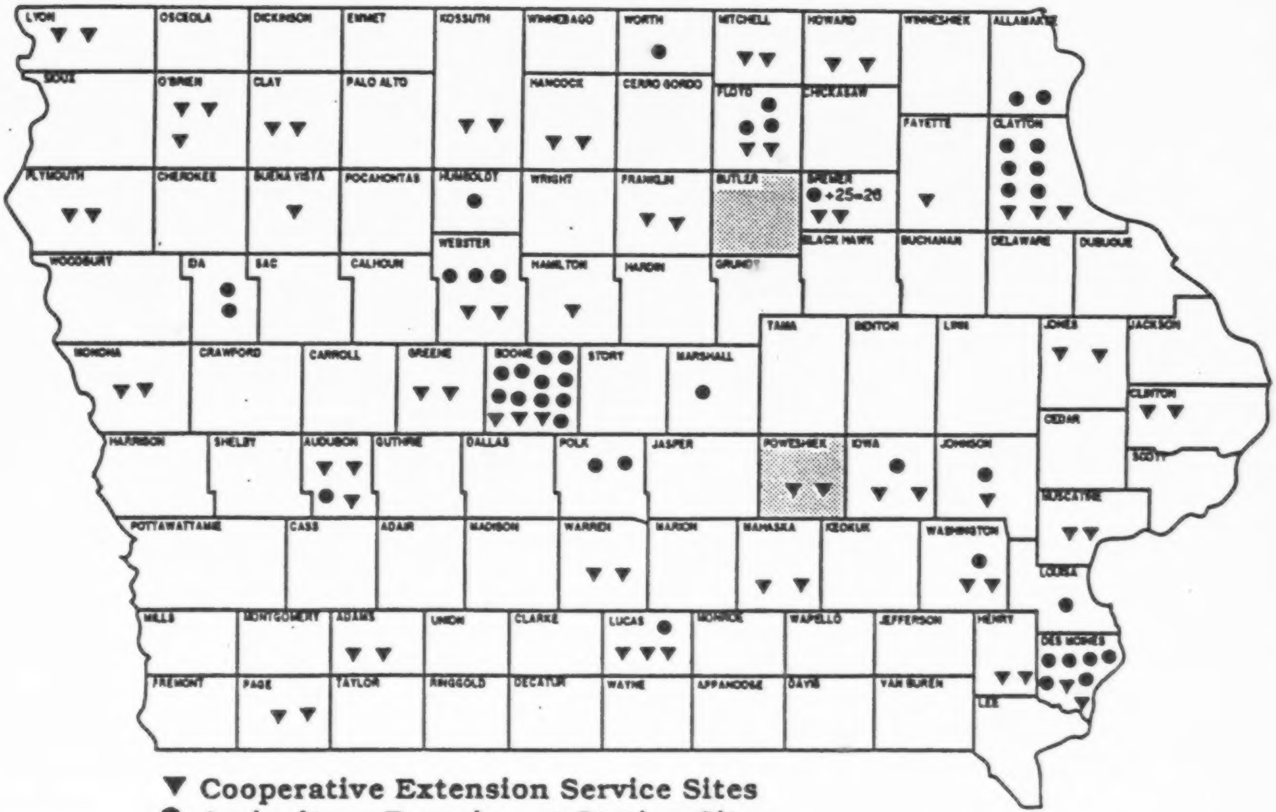
Integrated Farm Management Demonstration Sites - Iowa State University - 1988


LYON
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WINNEBAGO
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MITCHELL
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ALLAMAKEE
SIOUX
O'BRIEN
CLAY
PALO ALTO
HANCOCK
CERRO GORDO
FLOYD
CHICKASAW
FAYETTE
CLAYTON
PLYMOUTH
CHEROKEE
BUENA VISTA
POCAHONTAS
HUMBOLDT
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WEBSTER
BLACK HAWK
BUCHANAN
DELAWARE
DUBUQUE
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CALHOUN
HAMILTON
HARDIN
GRUNDY
TAMA
BENTON
LINN
JONES
JACKSON
MONONA
CRAWFORD
CARROLL
GREENE
BOONE
STORY
MARSHALL
CLINTON
CEDAR
HARRISON
SHELBY
AUDUBON
GUTHRIE
DALLAS
POLK
JASPER
POWESHIEK
IOWA
JOHNSON
SCOTT
MUSCATINE
POTTAWATTAMIE
CASS
ADAIR
MADISON
WARREN
MARION
MAHASKA
KEOKUK
WASHINGTON
LOUISA
MILLS
MONTGOMERY
ADAMS
UNION
CLARKE
LUCAS
MONROE
WAPELLO
JEFFERSON
HENRY
DES MOINES
FREMONT
PAGE
TAYLOR
RINGGOLD
DECATUR
WAYNE
APPANOOSE
DAVIS
VAN BUREN
LEE

▼ **Cooperative Extension Service Sites**
● **Agriculture Experiment Station Sites**
Shaded counties indicate county-wide demonstrations

Call your County or Area Extension Service Offices for names, locations, and details about the IFM Demonstrations.

Telephone numbers of Area Offices are:

Southwest, Atlantic	(712) 243-5750
East Central, Cedar Rapids	(319) 398-2040
Central, Urbandale	(515) 270-8114
North Central, Mason City	(515) 424-5432
Southeast, Ottumwa	(515) 682-8324
Northwest, Storm Lake	(712) 732-2584
Northeast, Waterloo	(319) 232-6654

INTEGRATED FARM MANAGEMENT
DEMONSTRATION PROGRAM

Butler County Project
IOWA STATE UNIVERSITY

Farm project demonstrates profits, environmental concern

PROGRAM PROFILE

Total acreage – 23,000 acres
Membership – 50 farms
Farms with livestock – 37
Range of farm size – 150 to 1,300 acres
Age range of participants – 24 to 78 years

PROGRAM OBJECTIVES

- Demonstrate the increase in farm profitability through the use of enterprise records, Integrated Nutrient Management, and Integrated Pest Management procedures
- Demonstrate that thorough planning and access to accurate field data throughout the cropping season will facilitate prudent and effective practices in pesticide and fertilizer use
- Provide a framework for the orderly transfer of the project from the public to the private sector over the three-year period
- Expand the project from the single model county to other Iowa counties

IOWA STATE UNIVERSITY
EXTENSION
Ames, Iowa 50011
IFM 1 | March 1989

Cooperators Ron and Eileen Krusey go over farm records with extension associate Tom Smidt.

While the debate on the practices, results, and even the definition of sustainable agriculture continues, 50 farm families in Northeast Iowa are reaping the benefits from one project of the Integrated Farm Management Demonstration Program.

The objectives of this Integrated Farm Management Demonstration Project are to demonstrate on-farm efficiency, energy savings, and profitability. In less than a year, the Butler County Integrated Crop Management on-farm projects are showing returns in real terms, in the amount of money saved and cropping practices implemented by participating farmers.

George and Lamar Chester, farmers in Butler County, avoided a loss of $42,000 for crop year 1988 by timely treatment for cutworms. Kevin Hummel, also a farmer in the Butler County area, saved $15,000 in fertilizer costs last crop season when soil fertility tests showed his land was "high" in phosphorus and potassium and did not require further P and K fertilization.

THE PROJECT

The Butler County Project was started after county, area, and state extension service personnel conducted informational meetings with Butler County farmers. The 50 Butler County farmers who chose to participate in the project were organized into five subgroups.

Hard work, research, interaction, support, and sharing of information are perhaps the key elements of the Butler County project.

FIELD SCOUTING

Field scouting involves detailed monitoring for insect damage, sampling for excess nutrient levels and nutrient deficiencies, weed control problems, crop diseases, abnormal crop growth, and checking for general and specific conditions that could affect crop growth and development.

Field scouts are involved in an ongoing weekly training program conducted by extension associate Tom Smidt, area crop production specialist Kay Connelly, and Butler county extension director Dale Thoreson.

The use of IFM practices has resulted in increasing farm profitability, reduction of energy input, and preservation of land resources.

The scouting experience was very worthwhile, Sarah Wefel said. Wefel is one of the six field scouts for the project.

Wefel said that her experience in scouting also helped her and her husband in running their farm.

"Often we look for weed pressure when we scout cooperators' fields," Wefel said. "We also check for insects, and take stand counts and population counts. Last season, I recall feeling funny about one field that I had scouted. The next week we found spider mites in the field."

Spider mites were a problem last season for Butler County dairy farmer Ron Krusey, who farms 306 acres and grows corn, soybeans, oats, and hay.

"Scouting is most beneficial," Krusey said. "It helps a lot with insect control. Last year, my fields had spider mites, and the project coordinator told me what to spray, when, where and how much."

In addition to regular meetings, project coordinator Tom Smidt meets with farmers once a week and discusses the condition of their fields based on the field scouts' reports and information.

1988 CROP SEASON

In the last crop season, all crop acres were scouted weekly, and soybean acres were scouted twice a week during the spider mite explosion. In addition, soil sampling of all crop acres was completed and crop enterprise records were initiated for each cooperator. Crop enterprise records include information on work done in each field, seed used, fertilizer, tillage and planting operations, herbicide, insecticide, cultivation, crop yield, special conditions, and specific problems.

The efforts of field scouting, problem solving with a proven knowledge base, principles of Integrated Pest Management (IPM), and maintenance of records have already begun to show results.

For some farmers, soil testing highlighted soil fertility problems. With others, corn rootworm and cutworm were detected and treated. Spider mites were a problem in the last crop season, and timely action helped several farmers limit damage to crops. Early detection helped control weed populations on farms. Indirectly, machine and power costs decreased.

Involvement in the project saved Kevin Hummel, a Butler County farmer, up to $15,000 on fertilizers. Soil tests showed his land "high" in phosphorus and potassium.

The use of IPM practices has resulted not only in increasing farmers' profitability but also in the reduction of energy input and preservation of the land by protecting the soil and water resources.

Even where IPM called for the use of pesticides to control the spider mite explosion, for example, field scouting allowed treatment only in needed areas and avoided the expense and environmental impact of broadcast applications throughout the area.

Follow-up meetings with the farmer cooperators on the role of the project, its usefulness, and future have received strong and positive comments. The transfer of the program from public to cooperator support over a three-year period was initiated by a $1.50 per crop acre charge for the 1989 crop year.

For more information on the project, contact the Butler County Extension office, Box 368, 303 1/2 N. Main, Allison, Iowa 50602.
Phone: (319) 267-2707.

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Cooperative Extension Service, Iowa State University of Science and Technology and the United States Department of Agriculture cooperating. Elizabeth A. Elliott, interim director, Ames, Iowa. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914.

This project has been supported, in part, by the Integrated Farm Management Demonstration Project of the Agricultural Energy Management Fund, State of Iowa, through the Iowa Department of Agriculture and Land Stewardship, with appropriations from the Iowa Groundwater Protection Act.
Extension Communications, 103 Morrill Hall, Iowa State University, Ames, IA 50011.
Editor: Muktha Jost

ACT-PEST-10

Pesticide Management

The following practices are or will be part of my pesticide management plan.

Planned ____
Applied ____

1. Read & Follow Pesticide Labels

Each pesticide has a label which contains information such as, rate of application, safe handling procedure, target pests, and known environmental hazards. A label is the most complete source of information about any given pesticide. It is against Federal Law and voids the liability of the manufacturer to apply a pesticide outside of label recommendations.

Planned ____
Applied ____

2. Crop Scouting

Fields are scouted in order to identify pest problems, potential pest problems, and when economic threshold levels have been reached. Pesticides don't need to be applied for problems that don't exist.

Planned ____
Applied ____

Banding of Herbicides and Cultivation

nding may cut herbicide use by 50-75%. Cultivators are available that will work under a wide variety of crop residue levels.

Planned ____
Applied ____

4. Follow Crop Rotation

Changes in crops disrupt pest life cycles and reduces the chance of a pest becoming a significant problem.

Planned ____
Applied ____

5. Pesticides Applied by a Certified Applicator

Private chemical applicators may be certified by attending a Cooperative Extension Service training session and passing a test.

Planned ____
Applied ____

6. Check Valves or Air Gaps

In order to prevent back-siphoning of chemicals into wells all pumps and hoses should be equipped with check valves or a planned air gap should be left between the hose outlet and the material in the spray tank.

Planned ____
Applied ____

7. Application Equipment is Calibrated

Calibration of liquid and granular applicators is important in order to apply the planned amount of pesticide. It is evident that underapplication of the desired amount of pesticide may lead to less yield due to pest damage. Overapplication may also lead to less yield due to crop damage, as well as being more expensive than application of the correct amount of pesticide.

Calibrate equipment at the beginning of each spraying period. Daily calibrations are important after installation of new nozzles.

Planned ____
Applied ____

8. Reduce Soil Loss to Tolerable Levels

Soil is the largest pollutant by volume of our surface waters. Herbicides that are bound to soil can move with the soil into surface waters and become a pollutant. Herbicides are generally surface applied or shallow incorporated into the soil. If erosion occurs it is this zone of herbicide application that will move taking the herbicides with it..

Planned ____
Applied ____

9. Proper Pest Disposal and Storage

Burnable containers may be burned. Non burnable containers should be triple rinsed, crushed and disposed of in an approved landfill.

Unused pesticides should always be stored in the original container under lock and key.

Planned
Applied ____

10. Soils Knowledge

Be knowledgable about the soils where pesticides are being applied. Soil conditions such as percent organic matter, pH, depth to bedrock, depth to water table, have an impact in how pesticides are applied in order to maximize the benefit with the least environmental damage.

Planned ____
Applied ____

11. Pesticide Rotation

Rotating the type of pesticides used helps prevent the buildup of target pests with resistance to a single pesticide.

U.S. Department of Agriculture
Soil Conservation Service

Iowa

Iowa Job Sheet Agron-12
June 1988

REDUCING GROUNDWATER CONTAMINATION EXERCISES

Divide participants into groups to complete the following activities:

1. Your group has been called upon to give a speech on the topic "How Can I Change My Pest Management Practices To Reduce Groundwater Contamination?" Prepare an outline of major points to emphasize in your speech.

   (Alternate activity: Prepare a ten minute speech on this subject and give at a community meeting.)

2. Your group has been asked to plan a field day for farmers in your community to demonstrate important management decisions and practices which will reduce groundwater contamination. Before you can make specific plans for the field day, you need to decide what are the major points that need to be demonstrated, so farmers will know how to reduce groundwater contamination. Develop a list of demonstrations which need to be included in the field day, illustrating the important pest management practices to reduce groundwater contamination.

   (Alternate activity: Make plans and arrange for a field day to carry out these demonstrations.)

3. Your group has been asked to prepare a display for your county fair which will illustrate the most important pest management practices to reduce groundwater contamination. Make a list of these practices that needs to be illustrated in your display.

   (Alternate activity: Make plans, develop and arrange for this display at your county fair.)

KEY-ACT-PEST-11

REDUCING GROUNDWATER CONTAMINATION EXERCISES

(Use VM-PEST-5 in conjunction with this key)

Each group should have included the following points:

1. Learn All You Can About Pesticides - Increasing complexity of chemical use requires that both the farmer and custom applicator thoroughly understand how pesticides should be handled and used, including their limitations and hazards.

2. Read and Follow Labels - Read, reread and follow label directions including safe handling, disposal, rate variations required for soils with different clay and organic matter contents, and carry over effects as it relates to your crop rotation.

3. Calibrate Sprayer - Insure that your sprayer is applying the rate specified by the label to reduce environmental risks, save energy and costs.

4. Rotate Crops and Farming Practices - Introducing other crops into the rotation such as legumes will help break up insect cycles, diseases, weed populations and reduce need for pesticides. Tillage practices such as contouring and conservation tillage will reduce erosion and retain pesticides that may wash off in sediment.

5. Use Pesticides Only When Needed - Consider biological and cultural practices first and then apply pesticides only when needed and economically justified.

6. Consider Cultivation in Lieu of Pesticide - Use of herbicides in row crops can be reduced by banding over the row and cultivating in between rows. Cultivating on the contour and adjusting shovels to minimize residue incorporation can reduce erosion risks. Contour ridge tilling should be considered.

7. Identify High Risk Areas - Locate highly permeable soils where special precautions may be needed to prevent groundwater contamination. Generally risks are greatest on sandy, gravelly soils; soil overlying either limestone or fractured bedrock; areas with a high water table and shallow wells; and land draining into ag drainage wells, abandoned wells or sinkholes.

STEPS TO REDUCE GROUNDWATER CONTAMINATION

1. Learn all you can about pesticides.

2. Read and follow labels.

3. Calibrate sprayer

4. Rotate crops and farming practices.

5. Use pesticides only when needed.

6. Consider cultivation in lieu of pesticides.

7. Identify high risk areas.

Managing Agricultural Pesticides

LESSON 2: Handling Pesticides Safely

GOAL:

Safe handling and storage of pesticides is essential to reduce environmental and health risks.

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

1. Compare the responsibility of pesticide users in safe handling to the methods used by farmers that you know.
2. Identify equipment needed for safe handling of pesticides.
3. Analyze the requirements for safe storage of pesticides and determine if most farmers use these precautions.
4. Evaluate the extent of readiness of farmers in using first aid and emergency procedures in case of accidental contact with a pesticide.
5. Describe the proper procedure for reporting a pesticide spill.

MATERIALS & REFERENCES:

Groundwater flow model, Groundwater Flow Model Manual, video player, video - Groundwater and Agricultural Chemicals: Understanding the Issues, Pesticides and Groundwater: A Health Concern for the Midwest.

ACTIVITIES:

ACT-SAFE-1 & Key	Groundwater and Agricultural Chemicals -- Understanding the Issues
ACT-SAFE-2	Pesticide Storage
ACT-SAFE-3 & Key	Controlling a Pesticide Spill
ACT-SAFE-4	Can you pass this test?
ACT-SAFE-5 & Key	Reporting a spill

INFORMATION:

INFO-SAFE-1	Pesticide Storage
INFO-SAFE-2	First Aid - In Case of Accidental Contact
INFO-SAFE-3	How to Handle an Emergency
INFO-SAFE-4	Reporting a Chemical Spill
INFO-SAFE-5	Communications System
INFO-SAFE-6	Proper Disposal of Pesticides

INTEREST APPROACH:

Walk into the room wearing the protective gear recommended when working with pesticides. Take off the equipment in front of the participants. As you take off a piece of equipment, ask the participants what the equipment guards against. Emphasize the importance of wearing safety equipment and following label directions when working with pesticides. Situate other safety items (things not worn) in the classroom so participants can identify them and state their purpose.

TEACHING PROCEDURE:

1. Distribute ACT-SAFE-1 and review the questions prior to showing the video "Groundwater and Agriculture Chemicals - Understanding the Issues." After showing the video, discuss answers to the questions using KEY-ACT-SAFE-1. Following the showing of the video, clarify - grass waterways do not prevent run-off, they help slow run-

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Prepared by Martin Frick, Department of Agricultural Education, Iowa State University, Ames, Iowa, June, 1989.

off water, reducing potential for erosion and serve as a filter by trapping some chemical attached to the sediment.

2. Introduce a discussion of pesticide storage by asking the questions 1, 2, 3, and 6 on ACT-SAFE-2. After some trial answers by the class, distribute INFO-SAFE-1 and allow participants to discover the answers.

3. Use ACT-SAFE-3 & Key to simulate a large pesticides spill and to identify actions for containing spills or leaks.

4. Use ACT-SAFE-4 to acquaint participants with pesticide applicator training and the knowledge needed to apply pesticides safely. (Answers are: 1=C, 2=D, 3=D, 4=A, 5=B, 6=A, 7=C, 8=A, 9=C, 10=A, 11=B, 12=A, 13=D, 14=C, 15=B).

5. Review why pesticides can be a health problem, using "Pesticides and Groundwater: A Health Concern for the Midwest." Use INFO-SAFE-2 & 3 in a discussion of how to handle an emergency and first aid in case of an accident. Are you or farmers you know prepared to respond to a pesticide emergency of first aid situation? What could we do in our community to help prepare them?

6. Ask the questions on ACT-SAFE-5 in a discussion of the reporting of a pesticide spill. Emphasize the key points using KEY-ACT-SAFE-5. Use INFO-SAFE-4 and 5 in describing the proper procedure for reporting a hazardous materials spill in Iowa.

7. Use INFO-SAFE-6 and questions 4 and 5 on ACT-SAFE-2 (answers on INFO-SAFE-1) in a discussion of proper disposal of pesticides.

8. Ask: If we were to develop a community educational campaign on how to safely handle and store pesticides what are the key points that should be included? Write answers on chalkboard.

OTHER ACTIVITIES:

1. Develop a chemical storage survey to collect data for chapter, community or adult/young farmer chapter. Contact a qualified evaluator, other than the agricultural instructor, to evaluate the data collected. The survey should solicit information about chemicals found, readable labels, empty containers, storage area conditions, and possible locations for storage. Locations could include home, garage, machine shed, and in machinery.

2. Invite professional pesticide applicator from a community agribusiness to talk to participants about safety regulations and safety features of equipment used by the company.

3. Demonstrate proper method of filling nurse and/or spray tanks used for pesticide use. Make sure participants wear proper safety equipment.

4. Develop safety display for use at local fair. Display may want to include protective equipment used in handling chemicals.

SUMMARY:

Pesticides are now being detected in low concentrations in shallow groundwater throughout the state. Although their evidence is lacking regarding the effects of human health resulting from chronic exposure to pesticides, their presence in groundwater clearly indicates water quality degradation. It is estimated that about 27% of the state's population is periodically consuming low concentrations of pesticides in their drinking water. It is imperative that safe storage and handling of agricultural chemicals be adhered to. If a chemical spill occurs in your area, be sure that proper state and federal officials are notified.

Discussion questions for video entitled "Groundwater and Agricultural Chemicals - Understanding the Issues".

1. What fraction of America's population depends on groundwater?

2. What percent of our drinkable water comes from the ground?

3. What is the responsibility of pesticide users?

4. What "human-made" pollutant can specifically be attributed to agriculture?

5. Name three ways pesticides reach our groundwater supply.

6. What are the top priorities for the safe handling of pesticides? From your experience, which of the safe handling methods shown in the video, are most often violated?

7. Who is the sponsor of this video?

8. In your opinion, what were the objectives the producers wanted to accomplish with this video? Why?

FOR DISCUSSION: Can the parallel needs of safe groundwater and successful farming practices that include the use of pesticides be attained?

ANSWERS TO DISCUSSION QUESTIONS FOR VIDEO ENTITLED "GROUNDWATER AND AGRICULTURAL CHEMICALS - UNDERSTANDING THE ISSUES"

1. ANSWER: 1/2 of our population.
2. ANSWER: 90%
3. ANSWER: Ensure the proper mixing, loading, applying, and disposing of chemicals so that they do not become point sources of groundwater pollution.
4. ANSWER: Pesticides
5. ANSWER: Leaching, surface runoff, and direct paths.
6. ANSWER:

   FILLING OPERATIONS
   a. Guard against back siphoning pesticides into your well.
   b. Fill nurse tank with water and take to field before pesticides are added.
   c. Fill spray tank first and pour pesticides in last.
   d. Water hose should be above tank and out of liquid if you must put in pesticides last.
   e. Always use check valves to prevent back siphoning.
   f. Never leave filling operation unattended.

   WELL PROTECTION
   a. Check current state guidelines concerning pesticide filling near wells.
   b. Never store agriculture chemicals close to well.
   c. Do not carry chemical inventory.
   d. Do not fill up, handle or apply in the vicinity of a well. Use additional hose and check valves.

   PESTICIDE CONTAINERS
   a. Pressure wash or triple rinse all containers.
   b. Pour rinse water into tank and apply to field.
   c. Make sure containers are leak free and tied down during transit.
   d. Maintain grass waterways.
   e. Practice good conservation management techniques, being particularly careful in applying pesticides near ponds or streams.

   CLEANING
   a. Minimize volume of rinse water.
   b. Spray rinse solution back on field.

** FINALLY - READ AND FOLLOW LABEL DIRECTIONS AND USE LOWEST EFFECTIVE RATE

7. The Monsanto Corporation, National Corn Growers Association and American Soybean Association
8. The producers wanted to illustrate that agrichemicals need to be used, but used safely. Although the information presented in the film provides pesticide users with some proper management practices, the sponsors present their views in attaining their objectives.

ACT-SAFE-2

PESTICIDE STORAGE

1. Where should pesticides be stored?

2. What should be done to keep stored pesticides safe?

3. List the tips for safe pesticide storage.

4. List the best solution for disposal of excess tank mixture of pesticides.

5. List the steps in the proper disposal of pesticide containers.

6. Do you or farmers you know follow the above safe storage precautions and, if not, why?

PESTICIDE STORAGE

Pesticides are usually purchased before they are needed, and must be stored between the time of purchase and use. Store them properly to prevent possible damage or hazard to:

1. People, especially children
2. The environment
3. Pets and domestic animals
4. Materials and containers

Store pesticides in a separate building away from other farm structures, if possible. The structure should be located away from wells. It should be located on high ground with good drainage and be accessible to trucks and equipment for delivery and removal under any weather conditions.

Lock storage area securely to keep children, pets, and irresponsible adults out. Post warning signs in a visible location.

Follow these tips for pesticide storage.

1. Always store pesticides in the original, tightly-closed containers. Labels must be attached and legible.
2. Stack containers only if the bottom ones are strong enough to support the stack without splitting open and spilling the material.
3. Read the label for storage instructions.
4. Store herbicides away from the insecticides, fungicides, seed, fertilizer, and similar materials.
5. Use the materials in a package only if you are confident of its contents and condition.
6. Don't store materials unnecessarily. See INFO-SAFE-6 for guidance in the proper disposal of:
   * Materials that are no longer registered.
   * Empty or unlabeled containers
   * Spilled materials
7. Keep fire away from the storage area. Do not permit smoking in or near the pesticide storage area.

CONTROLLING A PESTICIDE SPILL

MATERIALS NEEDED:

1. Water
2. Food coloring
3. Kaolinite clay or clean cat litter
4. One spoon
5. Sprinkler can

DIRECTIONS:

Pour water in sprinkler can. "Contaminate" water by pouring yellow food coloring in water. If possible, weigh the "contaminated water." Pour the "contaminated water" in a concentrated area on the groundwater flow model. Participants should be ready to form a clay dike around the spill area to simulate actual containment of a spill. After the "contaminated water" has been absorbed by the dike and the soil, remove all contaminated soil with a spoon and pour into a container. Weigh the amount of soil and water that had to be removed to clean up the soil. Check the total weight of the soil and water to that of the "contaminated water", weighed earlier. Compare the amount of simulated waste removed from this simulated spill to a potential spill while handling pesticides.

*** Use the experiment to assist in answering the following questions.

1. What type of soil would be most affected by a pesticide spill?

2. How could permanent pesticide storage facilities be designed to contain any pesticide spills or leaks?

KEY-ACT-SAFE-3

1. A soil that is low in moisture and a sandy texture.

2. Permanent pesticide facilities have a moisture-tight seal constructed below the surface of the facility to contain any spills or leaks from pesticide storage facilities.

CAN YOU PASS THIS TEST?

Before the Iowa legislature revised the pesticide law in 1987, all a farmer had to do to be approved for applying pesticides was attend a training session. He or she filled out a form at that meeting and sent it along with $5 to the Iowa Department of Agriculture. In return, the farmer received a card to prove he or she attended the proper training session. However, according to the new law, anyone who applies a restricted use pesticide must now take an exam to become certified.

The exam is a 50 question multiple choice test. You can buy a study guide for $5. Correct answers must be given to 35 questions. The test covers safe handling of chemicals; pesticide laws and regulations; calibration of equipment; pest management for insects, weeds, and diseases; and the effects of chemicals in groundwater.

The following test is not the real test, but these sample questions give you an idea of what the private applicator certification exam is like.

1. **Which pesticide formulation requires mechanical agitation to maintain the pesticide in suspension?**
   a. soluble powders b. granulars c. wettable powders
   d. emulsifiable concentrates

2. **Which group of people has the greatest rate of pesticide death in this country?**
   a. commerical applicators b. industrial plant workers
   c. farmers d. children

3. **Pesticide in a (an) ______________ formulation may be absorbed through the skin?**
   a. granular b. wettable powder c. emulsifiable concentrate d. all of the above

4. **During which stage of growth for many insects does most crop damage take place?**
   a. larvae b. pupal c. adult d. egg

5. **Crop rotation is what type of pest control?**
   a. mechanical control b. cultural control
   c. biological control d. legal control

6. **The downward movement of a pesticide in the soil is called?**
   a. leaching b. wind erosion c. water erosion
   d. all of the above

7. **The amount of nitrogen added to the soil by soybeans that yielded 40 bu. per acre is?**
   a. 160 lb. per acre b. 10 lb. per acre
   c. 40 lb. per acre d. none

8. **How can the risk of particle drift be reduced?**
a. use nozzles which deliver coarse sprays b. increase spray pressures c. use nozzles which deliver fine sprays d. decrease sprayer speed

9. **Clothing that becomes wet with concentrated pesticides should be:**
a. stored or washed with the family laundry b. sent to the dry cleaner c. destroyed d. given to charity

10. **Water soluble pesticides are most likely to leach through:**
a. sand b. clay c. organic matter d. none of the above

11. **Decreasing the forward ground speed of the sprayer will ___________ the amount of spray being applied to a specific area, if other factors remain unchanged.**
a. have no effect b. increase c. decrease d. maximize

12. **An insect which has a simple life cycle is:**
a. grasshopper b. corn rootworm c. European corn borer d. black cutworm

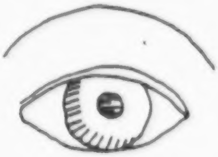
13. **Most weed seeds:**
a. can live for many years in the soil b. germinate from the top 1/2 inch of soil c. are stimulated to germinate by tillage d. all of the above

14. **Risk of Banvel drift injury to soybeans can be reduced by:**
a. spraying only when nearby soybeans are at least to bloom stage b. only spraying after June 20 in Iowa c. avoid spraying if temperatures are expected to exceed 85 degrees in the next few days d. using a higher spray pressure

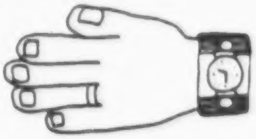
15. **Pesticides are toxic substances. The potential toxicity to human is stated on the label by use of "signal words." Which of the following "signal words" indicate the greatest toxicity to people?**
a. warning b. danger c. caution d. none of the above

Adapted from the **Wallace Farmer** - June 26, 1988. p. 17 - 20

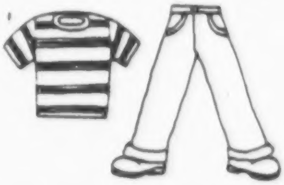
FIRST AID – IN CASE OF ACCIDENTAL CONTACT



Flush with water for 15 minutes. Get medical attention immediately. Refer to product label for further instructions.



Wash thoroughly with soap & water. Refer to product label for further instructions. If in doubt about nature of material, get medical attention immediately.



Remove contaminated clothing & wash skin thoroughly with soap & water. Refer to product label for further instructions. If in doubt about nature of material, get medical attention immediately. Wash clothing in strong detergent before reusing.

NOTE: If medical attention is sought, take labeled container.

This information is based on pre-fire plan and guidelines developed by Chevron Chemical Company and is reprinted by the National Agricultural Chemicals Association with their permission.

naca

NATIONAL AGRICULTURAL CHEMICALS ASSOCIATION
THE MADISON BUILDING
1155 Fifteenth Street, N.W., Washington, D. C. 20005
202 • 296-1585 Cable NAGRCHEM

How To Handle An Emergency Spill INFO-SAFE-3

1. Limit contact with the chemical.

   For example:
   Stay upwind from vapors.
   Stay out of anhydrous ammonia cloud.
   Don't walk in the spill.

2. Stop or reduce the amount of leaking, if possible.

   For example:
   Close valves between the leak and the tank.
   Pump the chemical out of the leaking tank.

3. Contain the spilled material on the surface.

   For example:
   Build a dike around the spill (such as shoveling dirt to make a dam) to prevent spread of chemical, especially to a stream or other surface water.
   Block storm drains or tile lines where spill may go.

4. Call the Department of Natural Resources Emergency Response: 515-281-8694.

REPORTING A SPILL

Using INFO-SAFE-4, ask the following questions related to reporting pesticide spills in Iowa:

Questions to consider:

1. What state agency is responsible to prevent the exposure of hazardous substances to the citizens of Iowa?

2. How much time is allowed to report a spill?

3. Is it the law that spills be reported?

4. What number do you call to report a spill?

5. What other numbers can be called in case of a spill?

6. What technical assistance can be provided?

7. List the first aid procedures to be followed in case of accidental contact.

8. What action should be taken to handle an emergency in the event of a spill?

KEY - REPORTING A SPILL

1. The Iowa Department of Natural Resources

2. Six hours are allowed before a spill has to be reported.

3. Yes. Iowa code 455B.382 requires all chemical spills, regardless of the quantity spilled, be reported to the Department.

4. Call 515-281-8694 to report a spill, 24 hours a day.

5. Note numbers listed on **communications system information sheet**. Note number for your area.

6. a. Technical information, toxicity data, and potential dangers, associated with a hazardous material.
   b. Monitoring and sampling air, water, and soil.
   c. Serving in an advisory capacity to first responders, spiller and cleanup contractors.

7. a. Flush eyes with water for 15 minutes.
   b. Get medical attention immediately. Refer to product label for further instructions.
   c. Wash thoroughly with soap and water.
   d. Remove contaminated clothing and wash skin thoroughly with soap and water.

8. Refer to INFO-SAFE-3

IOWA DEPARTMENT OF NATURAL RESOURCES

Field Evaluation & Emergency Response Bureau

HAZARDOUS MATERIALS SPILL RESPONSE

Under Iowa Code 455B.382, the Department of Natural Resources shall be the agency of the state to prevent, abate, and control the exposure of the citizens of Iowa to hazardous conditions defined as any situation involving the actual, imminent, or probable spillage, leakage, or release of a hazardous substance onto the land, into a water of the state, or into the atmosphere, which creates an immediate or potential danger to the public health or safety or to the environment.

REPORTING A CHEMICAL SPILL

A person manufacturing, storing , handling, transporting or disposing of a hazardous substance shall notify the Department of the occurrence of a hazardous condition as soon as possible but not later than 6 hours after the onset of the spill.

If the spiller, for some reason cannot notify the Department, he may notify the local police chief or county sheriff of the spill. The spiller must inform the police or sheriff he is reporting to them instead of the department.

TO REPORT A CHEMICAL SPILL ANYWHERE IN IOWA, 24 HOURS A DAY

CALL 515/281-8694

REPORTABLE QUANTITIES

Iowa law requires all chemical spills as defined above, regardless of quantity spilled, be reported to the Department.

WRITTEN REPORTS

If requested, a person shall submit within 30 days of the Department's request a written report of the particulars of the incident. A person violating the verbal or written requirement is subject to a civil penalty of not more than one thousand dollars.

IDNR RESPONSIBILITIES

For all environmental and chemical emergencies, the IDNR serves as the State's coordinator, with the exception of radiation incidents, in which case responsibility for response rests with the Iowa Department of Public Health.

IDNR Emergency Response operates out of its central office, 900 E. Grand Ave. , Des Moines, 50319. The three full time E.R. staff members are supplemented by field office staff operating out of 6 field offices throughout the state. After normal working hours and on weekends, state public safety radio answers all spill calls and notifies E.R. staff by pager.

IDNR E.R. staff can provide the following technical assistance:

1. Technical information regarding names, chemical and physical properties, toxicity data and potential dangers associated with a hazardous material.

2. Monitoring and sampling air, water and soil.

3. Serving in an advisory capacity to the 1st responders, spiller and cleanup contractors concerning:

    a. Containment of the material

    b. Safety precautions/ personal protection gear.

    c. Evacuation recommendations

    d. Disposal or treatment of the hazardous material or debris resulting from the spill.

    e. Listing of response contractors

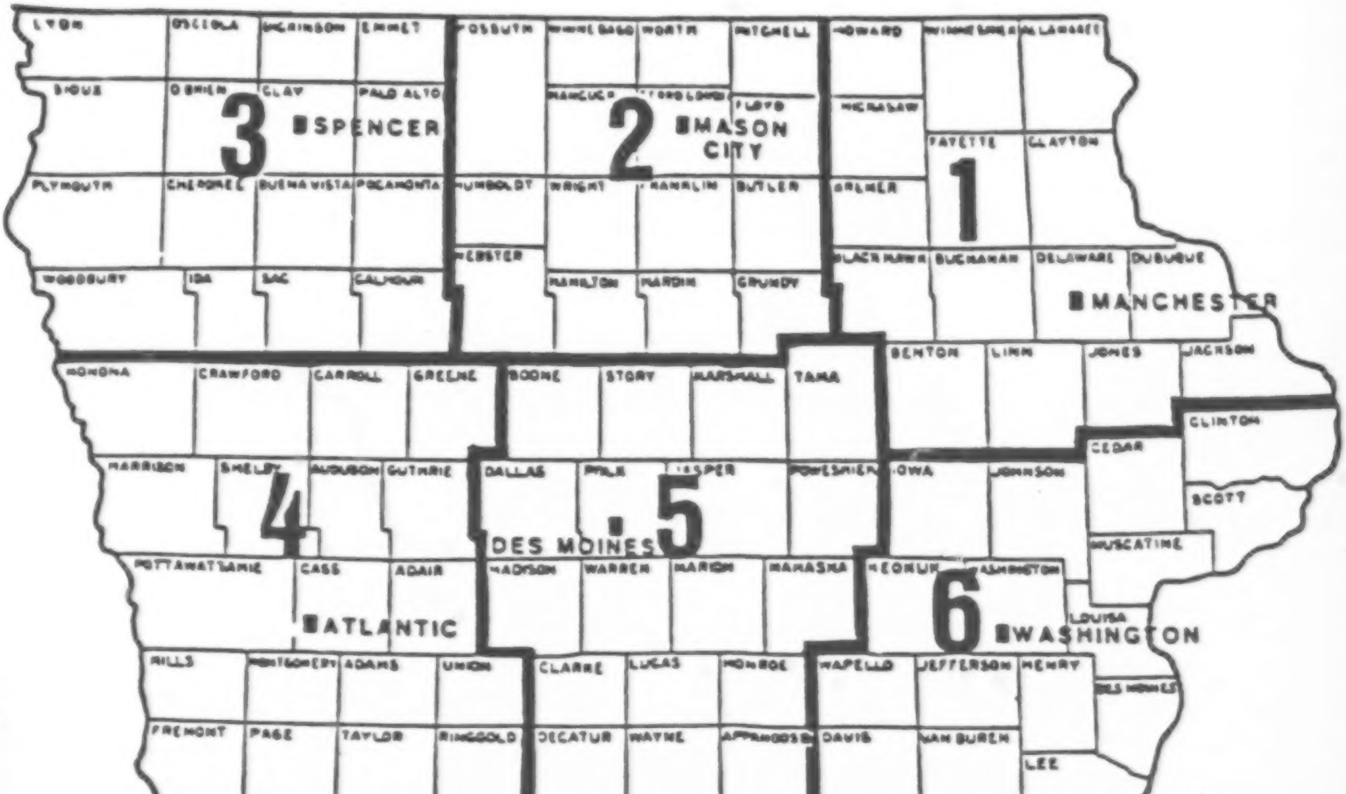
    f. Restoration of the environment

    g. Compliance with state and federal regulations.

In major incidents IDNR will dispatch a staff member to the scene. For minor incidents, IDNR will coordinate activities at the scene through telephone or radio communications with the first responders.

Communications
Appendix A1
Communications System

Office	Phone Number Office hours (8-4:30)	Communications Center (emergency)
Central	**24 Hour Spill Report No. statewide (515)-281-8694**	(515) 281-8694 State Public Safety Pager 197 (also at 515/281-3561)
Region 1	(319)-927-2640	(319) 927-3355 Manchester Police
Region 2	(515)-424-4073	(515) 421-3000 Cerro Gordo County Sheriff
Region 3	(712)-262-4177	(712) 262-3221 Clay County Sheriff
Region 4	(712)-243-1934	(712) 243-2204 Atlantic Police
Region 5	(515)-281-3622	(515) 281-3561 State Public Safety Pager 195
Region 6	(319)-653-2135	(319) 653-2107 Washington County Public Safety Center


3
SPENCER
2
MASON CITY
1
MANCHESTER
4
ATLANTIC
5
DES MOINES
6
WASHINGTON
LYON
OSCEOLA
DICKINSON
EMMET
KOSSUTH
WINNEBAGO
WORTH
MITCHELL
HOWARD
WINNESHIEK
ALLAMAKEE
SIOUX
O'BRIEN
CLAY
PALO ALTO
HANCOCK
CERRO GORDO
FLOYD
CHICKASAW
FAYETTE
CLAYTON
PLYMOUTH
CHEROKEE
BUENA VISTA
POCAHONTAS
HUMBOLDT
WRIGHT
FRANKLIN
BUTLER
BREMER
WEBSTER
WOODBURY
IDA
SAC
CALHOUN
HAMILTON
HARDIN
GRUNDY
BLACK HAWK
BUCHANAN
DELAWARE
DUBUQUE
MONONA
CRAWFORD
CARROLL
GREENE
BOONE
STORY
MARSHALL
TAMA
BENTON
LINN
JONES
JACKSON
CLINTON
HARRISON
SHELBY
AUDUBON
GUTHRIE
DALLAS
POLK
JASPER
POWESHIEK
IOWA
JOHNSON
CEDAR
SCOTT
MUSCATINE
POTTAWATTAMIE
CASS
ADAIR
MADISON
WARREN
MARION
MAHASKA
KEOKUK
WASHINGTON
LOUISA
MILLS
MONTGOMERY
ADAMS
UNION
CLARKE
LUCAS
MONROE
WAPELLO
JEFFERSON
HENRY
DES MOINES
FREMONT
PAGE
TAYLOR
RINGGOLD
DECATUR
WAYNE
APPANOOSE
DAVIS
VAN BUREN
LEE

INFO-SAFE-6

PROPER DISPOSAL OF PESTICIDES

Permanent disposal can be achieved in several ways. Proper use is the best method of permanent disposal. It is very important that private applicators buy only what they need and will use to avoid the penalty of disposal costs.

Excess tank mixture:

If an excess does occur, the best solution is to apply it to the crop in a manner consistent with the label. Rinse water may also be disposed of in this manner as long as the allowable rate of pesticide application is not exceeded. One should make every effort to avoid surplus mixtures and rinsates because these materials must be dealt with as toxic wastes which must be handled and disposed of as required by law.

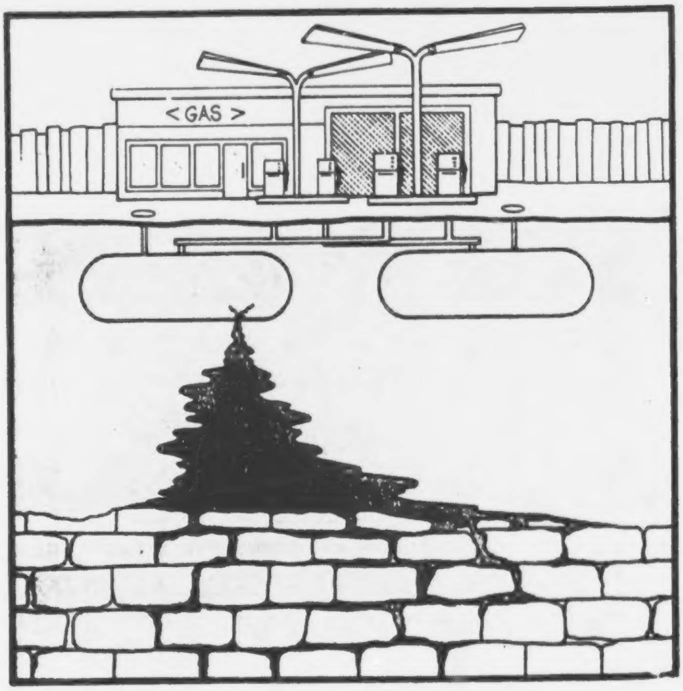
Empty containers:

Permanent disposal of containers is usually accomplished by one of two methods: burning or landfilling. Some paper or cardboard packages can be burned if allowed by label instructions and not prohibited by local ordinances. Burying waste on private property is now outlawed in Iowa without a permit.

The first step in the disposal of pesticide containers that cannot be burned is to triple rinse the containers (cans, jugs, drums and bottles) to remove as much pesticide as possible. After you have emptied the pesticide container into the spray tank, let the container drain completely. To rinse the container, fill it one-fifth to one-fourth full of water, close, then turn and up end the container so that all inside surfaces have been rinsed. Empty the rinse water into the spray tank. Let the container drain completely, at least thirty seconds. Repeat the rinsing procedure two more times, adding the rinse water to the spray tank each time. Triple rinsed containers can be disposed of as ordinary solid wastes in a sanitary landfill unless local ordinances prohibit the practice. Crushed containers require less storage space and are easier to handle in volume.

SOURCE: John Deere, Fundamentals of Machine Operation

MANAGING UNDERGROUND TANKS AND PIPELINES



EDUCATIONAL CONCEPTS

- Contents and problems
- Reducing leaks
- Economic impacts
- Health effects
- Energy conservation

Managing Underground Tanks and Pipelines

LESSON: Managing Underground Tanks and Pipelines

GOAL:

Leaks in underground tanks and pipelines can lead to groundwater contamination and cause health and environmental concerns. It is important to understand the problem and be able to prevent contamination of groundwater through these sources.

OBJECTIVES:

Upon completion of this lesson, the participants will be able to:

1. Locate underground tanks and pipelines in the local community and identify contents.
2. Identify the health, environmental and energy issues related to underground storing and transporting of petroleum products.
3. Analyze the economic and energy impacts resulting from leaking tanks and pipelines.
4. Evaluate alternatives to reduce leaks in underground tanks and pipelines.
5. Outline and explain legislation on underground tanks and pipelines.

MATERIALS:

Overhead Projector, Groundwater Flow Model or video and video player

VISUAL MASTERS:

VM-TANKS-1	Be Alert
VM-TANKS-2	Underground Tanks
VM-TANKS-3	Leaking Tanks
VM-TANKS-4	Benefits of Complying

ACTIVITIES:

ACT-TANKS-1 & Key	Word Puzzle
ACT-TANKS-2 & Key	Self-Help Checklist for Underground Storage Tanks

INFORMATION:

INFO-TANKS-1	Background on Leaking Tanks
INFO-TANKS-2	Health, Environmental and Energy Issues
INFO-TANKS-3	Impacts of Leaks
INFO-TANKS-4	Legislation Requirements
INFO-TANKS-5	Leak Detection Methods

INTEREST APPROACH:

Distribute ACT-TANKS-1 to participants and let them discover key words that will be the focus of this lesson. After a few minutes use KEY-ACT-TANKS-1 to emphasize the relationship between the words and groundwater quality. Place participant's answers to the following questions on the chalkboard: 1) What agricultural chemicals are transported and stored underground? Answers should include gasoline, diesel fuel, crude oil, natural gas and anhydrous ammonia, 2) What are other alternatives to storing and transporting these chemicals underground? Answers should include trucks and railroad, 3) Are underground tanks and pipelines safer in transporting and storing chemicals than the other alternatives? Answer - safer from fire and explosion but subject to leaks which contaminate groundwater.

Prepared by Thomas Lewis, Department of Agricultural Education, Iowa State University, Ames, Iowa, June 1989.

TEACHING PROCEDURES:

1. Use INFO-TANKS-1 for background information. Use ACT-TANKS-2 on a field trip to inventory the potential of local underground leaking tanks or, have participants inventory their own farm or another farm in the community making note of the location of underground tanks, all water sources, abandoned wells, streams, etc. Have them construct a map showing the exact location of the aforementioned. From these maps, discuss the relationship of where tanks are placed in relation to water sources. Use VM-TANKS-1 to direct awareness to the local community.

2. Ask the question: What is your best estimate on the number of miles of pipelines used for transporting products from one point to another in Iowa? (Answer: There are about 11,670 miles of pipelines in Iowa carrying natural gas, crude oil, anhydrous ammonia and other petroleum products). Pipelines are found in every county in Iowa. Nearly all of the products stored in underground tanks and transported through pipelines are hazardous and pose some threat to human health as well as wildlife and aquatic life.

3. Use VM-TANKS-2 to generate a discussion on the new technology using materials in manufacturing underground tanks and pipelines and causes of leaks and spills. Ask: What would cause leaks and spills? Answers should include 1) Holes due to corrosion of unprotected steel tanks and piping, 2) Improper installation of materials and backfilling, unapproved materials or pipe fittings incorrectly attached, 3) Spills and overfills when more product than the tank can hold is transferred or when the hose is improperly disconnected from the fill pipe. Refer to INFO-TANKS-4.

4. Using the groundwater flow model or portions of the video, illustrate how a small leak in a leaking tank pollutes groundwater, discharges into streams, rivers and lakes and can cause extensive damage. This may be done by injecting dye into the underground tank. Watch what happens when dye mixes with groundwater (stored in the aquifers) and discharges into the stream. Discuss the potential effect of such contamination on drinking water, fish and wildlife. Eight-five percent of the underground storage tank leaks reported in Iowa have resulted in contamination of shallow groundwater. The U.S. Environmental Protection Agency (EPA) reported that leaking storage tanks may be causing a serious risk to human health and the environment.

5 Have the participants identify health, environmental and energy issues related to the storage and transporting of petroleum products in underground tanks and pipelines. Refer to INFO-TANKS-2 for a partial listing.

6. Use VM-TANKS-3 to point out the extent of the problem of leaking underground tanks and pipelines.

7. Address the issues of economic and energy impact of leaking fuel tanks. Use INFO-TANKS-3 to summarize.

8. Have participants brainstorm methods or techniques to reduce leaks and spills in underground tanks and pipelines. Answers could include: 1) Monitor existing tanks: a) check regularly, b) Use test wells, 2) look for improper pipe and hose connections, 3) Be aware of change of taste of drinking water, 4) Do not transfer product unattended, 5) Call company representative before excavating around existing pipelines, 6) Weight benefits and risks of replacing underground tanks versus placing the tank above ground, 7) Install new tanks according to

standards and inaccordance with the Iowa Groundwater Protection Act.

9. Handout INFO-TANKS-4 and allow participants to review prior to asking the following questions: 1) What does the Iowa Groundwater Protection Act require underground tank owners to do? 2) What tanks are exempt? 3) What is required of underground tank owners with tanks less than or equal to 1,100 gallon capacity? 4) What is the requirement regarding registration tags? 5) If you had an underground tank that was installed in 1972, when must you have a leak detection device? Answer: 1991.

10. Use INFO-TANKS 4 and 5 to help plan activities that might help underground tank owners comply with the Iowa Groundwater Protection Act. Use INFO-TANKS-4 and 5 as a partial listing.

11. Using VM-TANKS-4, have participants develop a list of possible benefits in complying with the Groundwater Protection Act (summary found in the appendix), and the consequences when one does not comply.

OTHER ACTIVITIES:

1. Ask a service station representative to discuss the topic of underground tanks and pipelines and how they are complying with the Iowa Groundwater Protection Act.

2. Take a field trip to a farm or service station to see and hear how the owner is protecting against groundwater contamination.

SUMMARY:

Ask participants to give important points covered. List on chalkboard addressing each of the 5 objectives.

WORD PUZZLE

DIRECTIONS: Arrange the letters after each number to formulate a word or words which pertain to underground tanks and pipelines and be prepared to discuss the signficance of the word or words to the content of this lesson.

1. e g a l s n i o
2. r g e r t o a u w n d t t n o i e c p o r c t a
3. s z a r h d o u a c e s s t a n u b s
4. n e p l i p i e
5. d u r c e i l o
6. a h n d o u y r s a i o m m n a
7. c i m o n e o c t a p m i c
8. r w a t e y q l a u i t
9. r n l a t u a s g a
10. e l b a w e n e r n o n

KEY WORD PUZZLE

1. **gasoline** (Most common product stored in leaking underground storage tanks and pipelines)
2. **Groundwater Protection Act** (One of Iowa's laws addressing this source of contamination)
3. **hazardous substances** (Contained in underground tanks and pipelines)
4. **pipeline** (Over 11,000 miles in Iowa)
5. **crude oil** (Product stored and transported in underground tanks and pipelines)
6. **anhydrous ammonia** (Product stored and transported in underground tanks and pipelines)
7. **economic impact** (Leaks cost the public and individuals money as well as cost of cleanup)
8. **water quality** (The major end product in complying with the Iowa Groundwater Protection Act)
9. **natural gas** (Product stored and transported in underground tanks and pipelines)
10. **Nonrenewable** (Energy resource saved by preventing leaks)

BACKGROUND ON LEAKING TANKS

Underground tanks were originally required for the storage of some hazardous chemicals to reduce the danger of fire and explosion. The risk of contaminating groundwater, however, is increased because contaminants are closer to the groundwater table and the ability to detect leaks is greatly reduced. The impact of even a very small leak may be significant over the 20 to 50 year lifespan of an underground tank.

Over 150 incidents of leaking underground tanks have been investigated by the Department of Natural Resources over the past four and a half years (Figure 17). Contamination from leaking underground tanks have affected the public water supplies of eight communities in Iowa, and four have had to cease using specific wells.

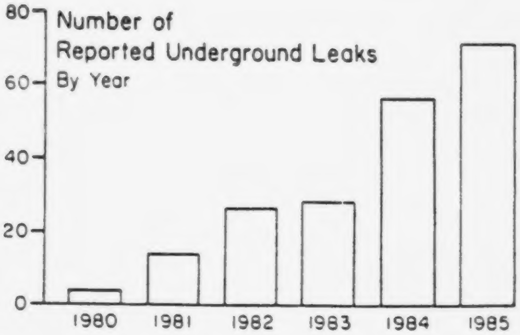


Figure 17. Number of Reported Leaks from Underground Storage Tanks. Source: Iowa Department of Natural Resources.

Nearly all of the products stored in underground tanks and transported through pipelines are of a hazardous nature and pose some threat to human health. Other risks involved with leaking underground tanks include fire and explosion, damage to wildlife, damage to plant life/crop loss, and damage to aquatic life.

Nationwide, 45 percent of the incidents of release from underground tanks have contaminated groundwater. Eighty-five percent of the underground storage tank leaks reported in Iowa have resulted in contamination of shallow groundwater.

Source: Iowa Groundwater Protection Strategy

SELF-HELP CHECKLIST FOR UNDERGROUND PETROLEUM STORAGE TANKS

	Yes	No
Are underground petroleum storage tanks present?	___	___
If no, do your neighbors have underground storage tanks?	___	___
Are the tanks used to store fuel for the home?	___	___
Are the tanks used to store agricultural chemicals?	___	___

If your answer is yes to one or more of the above questions, please continue to answer this checklist with a conscious mind. If your answer is no to any of the above questions, find someone with underground tanks and continue with the checklist.

	Yes	No
Do the tanks have a registration tag attached to the fill pipe?	___	___
Are the tanks made of fiberglass or corrosion-protected steel?	___	___
Are the tanks tested for leaks on a regular basis?	___	___
Were the tanks installed before 1965?	___	___
Are the tanks monitored on a monthly basis?	___	___
Are the tanks equipped with automatic shutoff devices or overfill alarms?	___	___
Are the tanks tested for leaks in more than one method?	___	___

Tanks of 1,100 gallons or less must have a permanent tag and tanks over that capacity must have a yearly tag attached to the fill pipe.

If the tanks on your farm were installed prior to 1965, the owner should either consider replacing it or employ rules and regulations as stated by the Groundwater Protection Act. If the tanks on your farm are not made of fiberglass or corrosion protected steel, the owner should take steps to replace it or provide some type of corrosion protection.

	Yes	No
Have the underground petroleum storage tanks been registered with DNR?	___	___
Are records of substances purchased and stored in tanks on your farm kept?	___	___

If your answer to the registration question is no, the owner has until October 1, 1989 to register without penalty. Minimum penalty for not registering is $7,500 by statute.

	Yes	No
Do you keep records of when your tanks were tested for leaks?	___	___
Are other records of maintenance and repair of equipment kept?	___	___

If your answer to any of the above questions relating to record keeping is no, you should devise some method of record keeping which proves whether you have or are complying with legislative requirements. If you are in doubt as to what to keep, keep it all.

Are underground storage tanks on your farm located near wells or other water sources?	___	___
Do you use your wells for both livestock and home use?	___	___

If your answers to the previous questions are yes, make it your business to see that all leak detection methods are used. Have your water tested on a regular basis.

BE ALERT

STOP

WHEN YOU SEE OR HEAR INFORMATION ABOUT TANKS AND PIPELINES

LOOK

AROUND OUR COMMUNITY AND FIND OUT WHERE UNDERGROUND TANKS AND PIPELINES ARE LOCATED.

LISTEN

TO WHAT IS BEING SAID ABOUT THE DANGERS ASSOCIATED WITH THE LEAKS OF THESE STORAGE AND TRANSPORTING FACILITIES.

UNDERGROUND TANKS

Replacement of aging steel underground storage tanks with such state-of-the-art fiberglass tanks as this is one technique which promises to assure protection of groundwater supplies from future contamination.

HEALTH, ENVIRONMENTAL AND ENERGY ISSUES

HEALTH ISSUES

Leaks of underground tanks and pipelines which store and transport agriculture chemicals that are toxic to humans, may cause chronic health risks.

If these agriculture chemicals leak into groundwater, there is no concentration at which the chemicals can be in a drinking water supply without some small risk of cancer.

In some cases a combination of chemicals contaminating water can produce health effects that are greater than the sum of their individual toxic effects.

Presently there is a lack of health effects information. The question is "can we afford to wait for research before we make a concerted effort to reduce this risk?"

ENVIRONMENTAL ISSUES

When chemicals from tanks and pipelines leak, they can seep into the groundwater and reappear as surface water in streams, rivers and lakes.

As a result, fish and wildlife may be destroyed as these chemicals poison their environment.

Polluted groundwater adversely affects living organisms in the soil.

ENERGY ISSUES

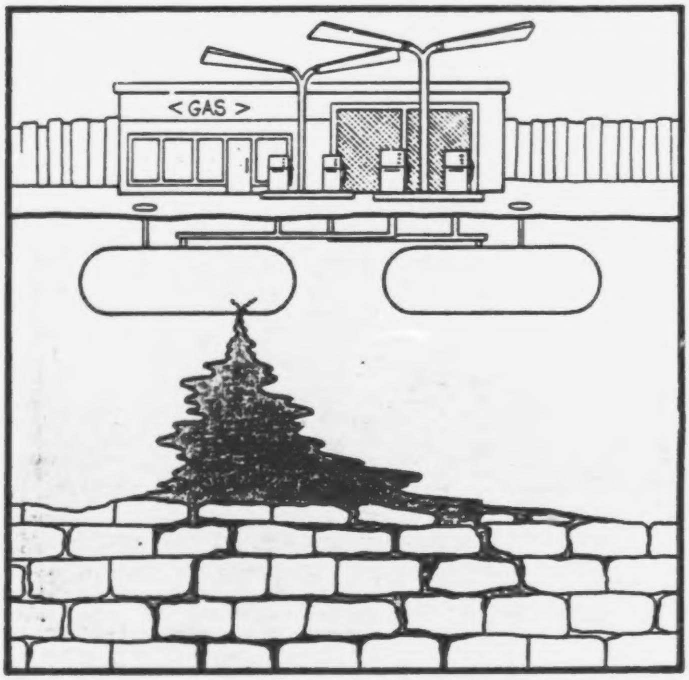
Leaks from tanks and pipelines increase the use of nonrenewable resources.

More energy is required in correcting and cleaning up leaks.

More energy is used when we manufacture more chemicals to replace those which were lost.

Energy is saved when leak detection methods are employed - thus preventing leaks requiring cleanup.

LEAKING TANK



(1) A LEAK OF 1 GALLON OF GAS PER DAY CAN CONTAMINATE THE WATER SUPPLY FOR A COMMUNITY OF 50,000 PEOPLE.

(2) 85% OF THE UNDERGROUND STORAGE TANK LEAKS REPORTED IN IOWA HAVE RESULTED IN CONTAMINATION OF SHALLOW GROUNDWATER.

IMPACT OF LEAKS

Economic Impacts

1. Economic (money) losses to the individual from loss of the chemical

2. Individuals may be forced to replace leaking tanks and pipelines

3. Individuals may be forced to pay stiff fines for environmental clean up work

4. Individuals or the public may be forced to restructure the environment damaged by leaking tanks and pipelines

Energy Impacts

1. Leaks increase the use of the petroleum products, a major source of energy

2. Using alternatives to petroleum can save nonrenewable resources and conserve energy

LEGISLATION REQUIREMENTS

Underground Storage Tanks (UST)

Goals of Rules

The goals of the underground storage tank rules are to prevent, find and correct leaks and spills from underground storage tanks (UST) and the problems they create.

Major causes for UST leaks and spills are:

* holes due to corrosion of unprotected steel tanks and piping.

* improper installation using poorly selected and improperly compacted backfill, unapproved materials, or pipe fittings incorrectly attached.

* spills and overfills when more product than the tank can hold is transferred or when the hose is improperly disconnected from the fill pipe.

You can request copies of the underground storage tank rules by writing: Records, Iowa Department of Natural Resources, Wallace State Office Building, Des Moines, Iowa 50319 or telephoning (for copies **ONLY**) 515/281-8897. If you have questions call 1-800-532-1114.

Legislation requires tank owners to:

a. Certify that the tanks and piping are installed properly according to industry codes

b. Equip the underground storage tank with devices that prevent spills and overfills

c. Protect tanks and piping from corrosion

d. Equip both the tank and piping with leak detection

What Tanks are Exempt?

The following UST systems are not regulated under Iowa UST rules:

1. Tanks used for storing heating oil for consumptive use on premises where stored.
2. Septic tanks
3. UST systems with capacity of 110 gallons or less.

4. Farm and residential tanks less than or equal to 1,100 gallons and installed prior to July 1, 1987 must provide notification **before July 1, 1989.** There is no fee for notification and these tanks are exempted from the Chapter 135 rules. (Farm and residential tanks installed on or after July 1, 1987 are subject to all fees and Chapter 135 rules.)

Tank Notification

Owners and operators of regulated underground storage tank systems are required to complete and submit to the DNR notification form 148 by the date listed below (rule 135.3. For new tank installations the notification form must include the signature of the installer(s) certifying that the installation was completed in accordance to the rules, specifically 135.3(1)"d".

All petroleum underground storage tanks can be registered without penalty until October 1, 1989. The minimum penalty for not registering petroleum USTs by that date is $7,500 by statute.

Tank	Notification due date
New tank system	Within 30,days of installation
*Existing tank system	May 6, 1986 (deadline past)
Farm & residential tanks under 1,100 gallons	July 1, 1989

*Existing tank systems include tanks taken out of operation after January 1, 1974 unless the tank was removed from the ground prior to July 1, 1985.

Registration Tags

Underground storage tanks registered with the DNR are issued registration tags that must be affixed to the fill pipe of the tanks [subrule 135.3(5)]. A person who delivers a regulated substance is allowed to deposit the substance in a tank which does not have a DNR tag on the fill pipe only one time. The delivery person must, at the time the deposit is made, report the unregistered tank to the DNR and provide the owner of the tank with a DNR tank notification form. No further deliveries may be made until the tank is registered and tagged.

Tanks over 1,100 gallons capacity must have a yearly tag and must submit a tank management fee of $15 by January 15 of each year. Tanks 1,100 gallons or less capacity are issued a permanent tag.

Leak Detection Requirements

If your tank was installed	It must have leak detection by December of:
before 1965 or unknown	1989
1965-1969	1990
1970-1974	1991
1975-1979	1992
1980-1988	1993

Source: EPA: Musts for USTs September 1988, page 29
DNR: Groundwater Protection Fact Sheet Groundwater Storage Tanks, January 1989.

LEAK DETECTION METHODS

1. Tank tightness testing combined with inventory control (measurements are taken daily and compiled monthly). Tightness testing every five years.

2. Automatic Tank Gauging System - automated processes monitor product level and inventory control.

3. Monitor for vapors in the soil - samples of vapors in the soil gas surrounding the underground storage tank are taken.

4. Monitor for liquids in the groundwater - (the groundwater table near an underground storage tank) for the presence of released free product on the water table.

5. Interstitial Monitoring - detects leaks in the space between the underground storage tanks and a second barrier or wall.

Source: Musts for USTs. September 1988, pages 10 - 11

Benefits of Complying with the Groundwater Protection Act

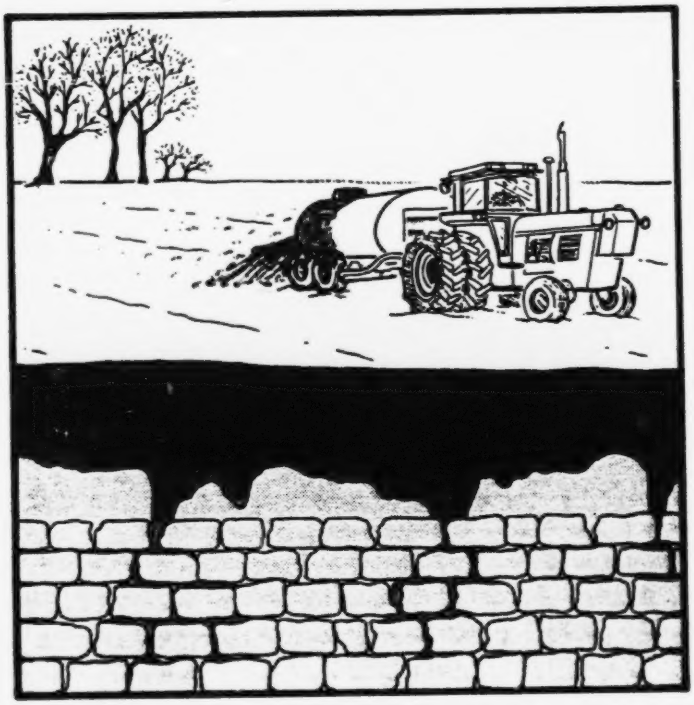
Consumer's Point of View

1. Clean drinking water and reduce health risk
2. Maintain fish and wildlife environment
3. Reduced energy use

Farmer and Petroleum Company Point of View

1. Avoid fines
2. Maintain a good public image
3. Avoid costs for clean-up of spills and leaks
4. Clean water supply

MANAGING NATURAL FERTILIZERS



EDUCATIONAL CONCEPTS

- Types of application
- Contamination reduction
- Health effects
- Energy considerations

Managing Natural Fertilizers

LESSON: Understanding the techniques for utilization of manures and other organic materials.

GOAL: Livestock wastes can be used as a resource rather than a source of groundwater contamination. Learning to manage this natural form of fertilizer can reduce the potential for water pollution as well as a supplement for crop nutrient needs.

OBJECTIVES:

After completion of this lesson the participants should be able to:

1. Compare the chemical and biological pollution sources in natural fertilizers.
2. Plan for the use of natural fertilizers as a resource that results in a cost effective and energy conserving crop production system.

MATERIALS:

SCS Water Quality Field Guide; A Guide for Safe Profitable Fertilizer and Pesticide Use; Waste Disposal ... Soil Surveys Can Help You; Pots for planting the seeds; Soils - from anywhere but be consistent; Overhead projector

VISUAL MASTERS:

VM-MAN-1	Advantages and Disadvantages of Manure Use
VM-MAN-2	Natural Fertilizer Management

ACTIVITIES:

ACT -MAN-1 and Key	Manure Calculations
ACT-MAN-2 and Key	Livestock Waste Management Plan

INFORMATION:

INFO-MAN-1	Advantages and Disadvantages of Manure Use
INFO-MAN-2	Natural Fertilizer Management
INFO-MAN-3	Livestock Waste Management Plan
INFO-MAN-4	Manure Analysis Laboratories

INTEREST APPROACH:

The pots should be prepared in advance, at least three weeks, and the seeds should be planted at this time.

1. Divide the participants into groups. Have each group collect different types of manure to use in this experiment.
2. Let the groups prepare pots of soil to plant their seeds.

   There should be a stipulation that the pots need an application similar to 140 pounds of nitrogen per acre as manure.
   Use ACT-MAN-1 and KEY.
3. Allow the participants to pick the pots in which they wish to plant their seeds. The pots should be numbered so that the instructor knows the contents.
4. Have the participants observe the growth of the plants while keeping a log of amount of water applied to each pot.

Prepared By Randy Bowman, Department of Agricultural Education, Iowa State University, Ames, Iowa, June,1989.

5. Call attention to the pots of growing or non-growing plants.

6. Have the participants brainstorm as to why some of the plants survived and why some of them died, or their growth differences.

7. Have them present their conclusions to the class.

   One alternative would be to hold a contest between the participants in which the participants brought the manure of their choice to use as the fertilizer. Which manure was the best as far as crop growth?

   A second alternative (or this could be used in conjunction with the interest approach and the first alternative or one of the above) would be to rinse the pots with water after the contest was completed and determine if any nitrate was available to be leached from the soil. (The instructor may want to prepare a dummy sample in which nitrate could be leached through the soil.)

TEACHING PROCEDURES:

1. Discuss the influence of factors associated with waste application that may have been a stimulant or deterrent to growth. Use VM-MAN-1 and INFO-MAN-1.

2. Use VM-MAN-2 and INFO-MAN-2 to discuss the management of natural fertilizers so that this resource can be used to its potential. (References - SCS Water Quality Guide, Chapter 8 and a Guide for Safe Profitable Fertilizer and Pesticide Use)

3. Use your soil survey report, INFO-MAN-3, AND ACT-MAN-2 in developing a livestock manure management plan for a local farm.

4. Direct participants in the proper techniques for collecting manure samples for testing their fertilizer value. Send samples of manure to a laboratory for testing. (Refer to INFO-MAN-4 for a listing of laboratories where tests can be made.)

OTHER ACTIVITIES:

1. Have the participants identify farmers in their area who use and do not use manures and then interview them to determine the effectiveness of manure application.

Examples should be tailored to the production practices in your area.

   Do you do this to supplement chemical applications?

   Do you do this to get rid of the stuff?

   How has manure application affected your crop management practices?

   How do the soils in your area react to manure applications?

   Do you believe that manure application does or does not affect groundwater quality?

   Do you think that the use of animal wastes is worth the effort needed to apply them?

2. Ask the participants to determine the groundwater quality issues in their area. Is there or is there not a problem or perceived problem in their area?

3. A field trip to a municipal waste treatment plant and discuss the problems associated with sewage sludge disposal.

4. Research the problems associated with an improperly designed septic tank and trace potential groundwater contamination.

5. Run percolation tests on soils in your area to determine the potential for septic tank groundwater pollution. (Use reference Special Report 87, Site Evaluation, Design, Operation, and Installation of Home Sewage Systems in Iowa, Iowa State University Cooperative Extension Service.)

SUMMARY:

It is important to remember that the benefits derived from natural fertilizers are very much dependent on good management practices and these management practices include immediate incorporation into the soil. The incorporation of these materials make them susceptible to the filtering properties of a soil thus reducing their availability. The pollution process consists of availability, detachment and transport and any method to diminish any of these stages will result in pollution reduction. Pollution by natural and chemical fertilizers is more dependent on availability than detachment or transport because detachment and transport can be influenced by the management system used.

It should be realized that manure application must be part of a total production system that generates manure. This entails the inclusion of some type of livestock in your production system. It can be a very viable system that, at its best, can eliminate the use of chemical fertilizers.

You have decided that the manure from your llama herd could be used to meet the nitrogen requirement for your corn crop. The soil report from the Iowa State University Soil Testing Lab says that you need to apply 140 lbs of nitrogen/acre for this crop. You discover that llama manure contains 25 lbs of nitrogen/ton of manure. You wish to do some research before applying this manure and you decide you want to simulate the amount needed by placing soil into a pot and applying llama manure to the soil in a pot. How are you going to determine how much manure you need to apply to simulate field conditions?

FILL OUT THE FOLLOWING CHART

						Pot Data		
Type of Livestock	Storage, handling	Total N lbs/ton*	Required tonnage	lbs	lb/sq ft	Pot Area	lbs/ pot	oz/ pot
Swine	Solid NB	10						
	B	8						
	Liquid P	36						
	L	4						
Beef Cattle	Solid NB	21						
	B	21						
	Liquid P	40						
	L	4						
Dairy Cattle	Solid NB	9						
	B	9						
	Liquid P	24						
	L	4						
Turkeys	Solid NB	27						
	B	20						
Horses	Solid B	14						

B = Bedding, NB = No Bedding, P = Pit, L = Lagoon

Required Tonnage is the tons of manure needed to supply a crop with 140 lbs of nitrogen/acre

lbs/sq ft is the pounds of the manure required for one square foot and is calculated by dividing the pounds needed by the surface area of 1 acre (43560 sq. ft.)

Pot area is the area of the pot at the soil surface and is determined by multiplying the radius of the pot times π.

The radius in inches squared needs to be converted to feet squared. This is done by dividing the area of the pot by 144 inches squared.

lbs/pot is determined by the area of the pot times the lbs/sq ft needed to apply the equivalent of 140 lbs/acre of nitrogen.

*Sutton et al., University of Minnesota Extension Bulletin AG-FO-2613

You have decided that the manure from your llama herd could be used to meet the nitrogen requirement for your corn crop. The report from the Iowa State University Soil Testing Lab says that you need to apply 140 lbs of nitrogen/acre for this crop. A little research needed to be done and you discover that llama manure contains 25 lbs of nitrogen/ton of manure. You wish to do some research before applying this manure and you decide to simulate the amount needed by placing soil into a 14 inch pot and applying llama manure to the soil in the pot to find out the effect of llama manure on crop growth. How are you going to determine this?

LET'S GO THROUGH AN EXAMPLE

1. How many tons of llama manure would be needed to be applied to meet the nitrogen requirement of 140 lbs of nitrogen/acre?

   140 lbs/acre divided by 25 lbs/ton = 5.6 tons/acre

2. You now know the tons/acre, but how many lbs/acre is this?

   To calculate the amount of manure, you need to divide the recommended rate by the amount of nitrogen that llama manure contains.

   5.6 tons times 2000 lbs/ton = 11,200 lbs/acre

3. How many lbs/square feet is this?

   You now know that it is going to take 11,200 lbs/acre to meet this requirement. There are 43560 square feet in an acre. To determine the amount/square foot divide 11,200 lbs/acre by 43560 square feet/acre.

   11,200 lbs divided by 43560 square feet/ acre = 0.26 lbs/square foot

4. You now know that it will take 0.26 lbs/square foot to fertilize an area with the equivalent of 140 lbs/acre of nitrogen.

How many square feet does the soil surface of your 14 " pot have?

1. The area of a circle is determined by multiplying the squared radius by π (πr^2).

   14 inch diameter pot would have a 7" radius.

   7" squared equals 49 square inches, and 49 square inches multiplied by 3.1416 (π) is 153.94 square inches.

2. How many square feet in 153.94 square inches?

   One square foot contains 144 square inches (12 in times 12 in =144 sq in) so dividing 153.94 square inches by 144 square inches will give the amount of square feet in a 14" diameter pot.

   153.94 square inches/144 square inches per square foott = 1.07 square feet.

3. The amount of llama manure needed to simulate a nitrogen application of 140 lbs/per acre would then be the square feet of the pot times the lbs/square feet.

   Area of the soil in the pot = 1.07 square feet/pot
   lbs/acre needed = 0.26 lbs/square ft

   1.07 lbs/square foot times 0.26 lbs/square foot = 0.28 lbs/pot

4. How many ounces is 0.28 lbs.

   lbs times oz/pound = ounces
   0.28 lbs times 16 oz/lb = 4.48 oz

So to simulate the application of 140 lbs/acre of llama manure in your 14" pot would require the application of 0.28 lbs or 4.48 oz to the soil surface of your pot.

If your pot size is not 14 inches or your rate of nitrogen application is not 140 lbs, you can substitute your pot size or nitrogen rate or both into the equations to determine the amount of manure needed to simulate your pot size and/or rate of nitrogen application.

Type of Livestock	Storage, handling	Total N /ton*	Required tonnage	lbs	lb/sq ft	Pot Size							
						12 in lbs	12 in oz	10 in lbs	10 in oz	8 in lbs	8 in oz	6 in lbs	6 in oz
Swine	Solid NB	10	14	28,000	0.64	0.50	8.00	0.35	5.60	0.22	3.50	0.13	2.10
	B	8	17.5	35,000	0.79	0.62	9.40	0.43	6.88	0.28	4.50	0.16	2.60
	Liquid P	36	3.89	7,780	0.18	0.13	2.13	0.10	1.60	0.06	1.01	0.04	0.58
	L	4	35	70,000	1.60	1.30	21.0	0.90	14.4	0.60	9.60	0.30	4.80
Beef Cattle	Solid NB	21	6.66	13,320	0.31	0.23	3.67	0.17	2.68	0.11	1.74	0.06	1.00
	B	21	6.66	13,320	0.31	0.23	3.67	0.17	2.68	0.11	1.74	0.06	1.00
	Liquid P	40	3.5	7,000	0.16	0.13	2.10	0.09	1.44	0.06	0.96	0.03	0.48
	L	4	35	70,000	1.60	1.30	21.0	0.90	14.4	0.60	9.60	0.30	4.80
Dairy Cattle	Solid NB	9	15.55	31,100	0.71	0.53	8.41	0.38	6.13	0.29	3.98	0.14	2.27
	B	9	15.55	31,100	0.71	0.53	8.41	0.38	6.13	0.29	3.98	0.14	2.27
	Liquid P	24	5.83	11,660	0.27	0.20	3.20	0.15	2.33	0.09	1.50	0.05	0.86
	L	4	35	70,000	1.60	1.30	21.0	0.90	14.4	0.60	9.60	0.30	4.80
Turkeys	Solid NB	27	5.18	10,360	0.24	0.18	2.84	0.13	2.07	0.08	1.34	0.05	0.80
	B	20	7	14,000	0.32	0.24	1.42	0.17	2.76	0.10	1.60	0.06	1.02
Horses	Solid B	14	10	20,000	0.46	0.34	5.45	0.25	3.97	0.16	2.58	0.09	1.47

B = Bedding, NB = No Bedding, P = Pit, L = Lagoon

Required Tonnage is the tons of manure needed to supply a crop with 140 pounds of nitrogen

lbs/sq ft is the pounds of the manure required for one square foot and is calculated by dividing the pounds by the area of 1 acre (43560 sq. ft.).

12 in = the figures under pot size are the amounts of the manure needed to be added to the pots to simulate a manure application of 140 lbs of nitrogen in both pounds and ounces.

The surface area of the pots was determined by multiplying the radius squared by π.

* = Sutton et al., University of Minnesota Extension Bulletin AG-FO-2613

VM-MAN-1

Advantages of Manure Use

1. Contains nutrients
2. Organic Matter
3. Micronutrients
4. Release Rate
5. Energy Conservation

Management to Overcome Environment, Handling, and Application Concerns

1. Disease Organisms
2. Pollution
3. Handling
4. Application

Advantages of Manure Use

1. Contain Nutrients - the nutrient content of manure varies. The type of livestock, the use and type of bedding, the feed source, and the collection and handling system all affect the nutrient composition of manure. The nutrient content per ton of manure can range from 4 to 40 pounds of nitrogen.

2. Organic Matter - manure contains a large amount of organic matter. This organic matter has been shown to improve soil tilth. Soil tilth is generally understood to mean the ability of the soil to be productive.

3. Micronutrients - manure often contains many of the micronutrients necessary for crop growth thus eliminating the need for application of many micronutrients.

4. Release Rate - manure releases the nutrients slowly as a result of decomposition. This slow release makes the nutrient more available to the plant during the growing season.

5. Energy Conservation - By using livestock waste to supply part of the nutrient needs of a crop, chemical nitrogen can be reduced. This reduction will decrease manufacturing, transportation and energy needs.

Management to Overcome Environmental, Handling, and Application Concerns

1. Disease organisms are the most important environmental concern. They have been shown to survive the digestive process of the animals from which the majority of manure originates. Spreading on the land or incorporation into the soil will prevent movement by water and thus reduce water pollution.

2. Pollution - manure can be both a point source and a non-point source of pollution much like nutrients and pesticides. The mechanism for pollution is much the same.

3. Handling - the storage and labor needed to use manure as a nutrient source can be time consuming but cost effective if properly handled.

4. Application - manure application is not one of the critical operations of most farmers thus the time to apply manure may compete for the farmer's time and labor.

Managing Natural Fertilizers

1. Tie applications to crop use
2. Incorporate
3. Consider erosion potential
4. Avoid excessive rates

"Treasure of Abundance or Pandora's Box?"
Soil and Water Conservation Society, Ankeny, Iowa.

MANAGING MANURE AND OTHER ORGANIC MATERIALS

Environmental risks presented by manures and sludges or "natural" fertilizers are much the same as those provided by commercial fertilizers. However, solutions for minimizing for environmental risks may be different.

1. **Tie applications to crop use** - Timing of manure and sludge application should be as close as possible to periods of use by the crop. Avoid spreading these materials on frozen soil or snow cover to minimize soluble nitrogen and phosphate losses resulting from runoff caused by rainfall or snowmelt. Applications during periods of evapotranspiration exceeding precipitation can also help minimize groundwater contamination.

2. **Incorporate** - Incorporation into the soil by injection or immediate tillage greatly reduces nutrient losses. However, plowing, disking or other tillage in the fall that buries most crop residue can increase soil erosion risks unless proper precautions are taken. Nitrification inhibitors may help reduce nitrogen losses also, if manure or sludge is incorporated, because nitrogen in manure or sludge typically is in the ammonium form.

3. **Consider erosion potential** - When necessary to apply these materials in the fall or winter, or when incorporation is impossible, select fields with low erosion and runoff potentials. Applications on well-established winter cover crops and on pastures and hay fields can reduce the potential for nutrient loss and surface water contamination.

4. **Avoid excessive rates** - Apply manures and sludges on soils having a high seasonal water table or rapid permeability at rates based on an analysis of their nutrient and heavy metal concentrations as well as yield goals. The risk of groundwater contamination is high on these soils. Use of nitrogen in manures and sludges may be low when applied to land intended for a legume crop.

"Treasure of Abundance or Pandora's Box?", Soil and Water Conservation Society, Ankeny, Iowa.

CONTROLLING ANIMAL WASTE POLLUTION*

Principles of Control

Manure is a valuable resource for crop production. It contains not only nutrients but also organic matter. If the nutrients in manure are conserved and judiciously reused, it will cause fewer water problems.

The availability of manure as a pollutant is reduced by the proper application rate, the proper time of application, incorporation of the manure whenever possible, and by the judicious selection of the application site. These measures will often require the storage of manure; however, storage by itself gives no water quality benefits. Storage is only a means to better utilize the nutrients and avoid spreading the manure during critical runoff periods, for example, when the ground is frozen or covered with snow and ice.

Methods of Control

1. A waste management system is a planned system in which all necessary components are installed to manage liquid and solid animal waste in a manner that does not degrade air, soil, or water resources. The system may consist of a single component such as a diversion, or it may have numerous components such as a storage facility, a method of transporting the waste to the application area, and the necessary equipment. The structural components most commonly used to control manure pollutions are waste storage ponds and structures, and waste treatment lagoons.

Waste storage ponds and *waste storage structures* may be required where animal waste is temporarily stored until it can be applied without creating a water quality problem. *Waste treatment lagoons* are used to biologically treat animal wastes to reduce the nutrient content and the oxygen demand. They are not a nutrient conservation practice. They are most often used with large animal enterprises where the manure is removed from confinement by flushing. Lagoons benefit water quality by returning nitrogen to the atmosphere from their surfaces. This is important where land and animals are out of balance; that is, the manure produced greatly exceeds the capacity of the land to utilize the nutrients in the manure.

2. Waste utilization is a management practice and probably the most important control practice. Normally, manure is applied to pastures and cropland to recover plant nutrients.

Water quality problems related to manure application sites can be effectively solved by practices that reduce the availability of pollutants for transport during runoff events, such as: 1) elimination of excessive application rates, 2) proper timing of manure applications, 3) proper method of manure application, and 4) selection of application sites. Application rates of manure should be based on soil nutrient levels, the nutrient needs of the crop, and the available nutrients in the manure. An exception is where pathogens are a problem such as in watersheds above shellfish growing areas. Both nitrogen and phosphorus requirements should be considered in determining proper application rates. Applying manure to satisfy crop nitrogen requirements may result in excess phosphorus being applied. The SCS Agricultural Waste Management Field Manual provides instructions for determining the application rate.

*SCS Water Quality Field Guide

The timing of manure applications should coincide as nearly as possible with crop needs to maximize plant nutrient utilization and reduce the potential for nutrient losses in runoff. Application should also be timed to coincide with tillage operations where possible.

The frequency of manure application is highly variable, ranging from daily to once per year, depending on the availability of manure, availability of labor, storage capacity, access to the disposal area, and the amount of land available. Daily spreading of manure is often practiced when animals are confined and storage facilities are not available. When manure is stored, a common design in the cool and cold areas of the country is to provide 6-month storage capacity. This results in two intensified periods of manure application, early spring and late fall.

Spreading manure on frozen or snow-covered soil is generally a practice that should be avoided because of the potential for losses during rainfall or snowmelt runoff. Manure storage is considered a pollution control practice because it avoids spreading during adverse periods. Applying manure that has been stored over winter may become critical in conjunction with spring tillage operations and spring rainfall. Applying manure in the fall increases the potential for nitrogen loss through leaching.

The *method of manure application* can greatly affect its availability for becoming a pollutant. The physical incorporation of manure by injection, immediate plowing or disking will dramatically reduce the runoff losses of manure nutrients. If manure is not injected in cropland, surface spreading should not be scheduled until the manure can be incorporated by a tillage operation.

Manure is normally topdressed on hay crops and topdressed or injected on pastures. Losses will generally be small if surface applications are light and the legumes or grasses provide good cover. Applications can be made after the animals have been removed from the pasture or following the cutting of the hay crop.

The *proper selection of application areas* is critical in avoiding the loss of nutrients from applied manure. The hazard of specific areas depends on their location, rainfall intensity, slope, vegetative cover, and soil characteristics. In selecting areas; land next to streams, lakes, and waterways should have low priority or be avoided if possible.

Where storage facilities are not available, field priorities for winter spreading should be established to reduce water quality hazards. This requires the ranking of available areas with respect to potential pollutant discharge. The proximity to steams and major drainage channels, slope, and the vegetative cover should be considered. Areas that have a high runoff potential should be avoided.

3. Soil and water conservation practices can aid in the reduction of pollution by animal wastes. Erosion control practices are applicable in reducing the loss of manure pollutants, particularly when manure is surface applied. Such practices as contour cropping, strip cropping, terraces, and conservation tillage are included.

Vegetative cover that provides soil protection during all or part of the non-growing season can influence pollutant loss in several ways. The increased cover and surface residue decrease soil erosion. Vegetative growth, especially from a well-established winter cover crop, can take up nutrients which would otherwise be lost and can serve as a filter to trap sediment adsorbed nutrients.

If pollutants are not being controlled adequately at the source, grass filter strips can be placed at field edges. These areas filter and trap sediment, manure, and other pollutants. Potential pollutants will then either decay, infiltrate the soil, or be taken up by growing plants. For the areas to be effective, they must slow runoff sufficiently to allow the sediment and organic materials to settle out in the filter. Filter strips can also be located along streams.

In some areas of the country, manure from dairy cows is applied only to hayland and pasture, often on soils that have a seasonal high water table. Here, the problem is not erosion and sedimentation but rather one of: 1) incorporation, 2) being able to travel over the field, and 3) preservation of the soil structure.

Manure in these areas is often applied as a liquid either by a liquid tank spreader or, if it has been diluted a number of times, by sprinklers. Incorporation by tillage is not possible, and injection is impractical. Thus, incorporation occurs only by infiltration. In this case it is imperative that the water table be low enough to allow the manure liquids to infiltrate readily into the soil. Subsurface drainage is necessary to lower the water table, allowing the manure liquids to infiltrate. Drainage also improves the trafficability of the soil, permitting hauling equipment to travel more of the land and for longer periods during the year without damage to soil structure.

4. Pastureland and rangeland properly managed and not overgrazed usually have no problem of pollution by animal waste. The key practices to be used with pastureland and rangeland are livestock exclusion, pasture management, proper grazing use, selected salt and feed sites, and selected shade areas. Principle water quality problems occur where animals congregate, where they have access to streams, and where supplemental feed is provided at wintering sites. Grazing livestock also tend to congregate in shaded and protected areas, adjacent to watering facilities, and close to salt locations. In addition to increased manure accumulation, soil compaction and destruction of vegetative cover occur in these areas. This results in soil erosion, increased runoff, and the discharge of pollutants associated with manure.

Livestock on pastureland and rangeland frequently have access to streams. This results in the direct deposition of feces and urine into surface waters. Animal traffic may cause streambanks to become unstable and create erosion.

Animal densities in wintering areas are much higher than those on grazing areas. This results in an increase in manure and pollutant concentrations in rainfall and snowmelt runoff. Fecal bacteria increase significantly around areas of greater livestock activity.

Water quality problems related to pastureland and rangeland are most effectively controlled by using sound management practices. Overgrazing should be avoided. Stocking rates and grazing systems that sustain good forage yields will minimize manure accumulations and reduce surface runoff. Maintaining good vegetative cover and minimizing soil compaction will greatly reduce runoff. The SCS National Range Handbook and SCS Technical Guides provide information on appropriate stocking rates for various animal species, types of vegetation, grazing systems, and geographic regions.

Winter pastures and areas of animal concentration, such as shaded and protected areas and water and salt facilities, should be located in areas hydrologically remote from streams and major drainage channels. This will minimize water quality impacts by allowing runoff waters to move through vegetative areas before entering the receiving stream. Manure accumulation around these areas can be reduced by periodic relocation of these facilities. Relocating the facilities will also help to alleviate overgrazing in the area immediately adjacent to them. Accumulations of manure in heavily concentrated areas can be removed periodically and applied to cropland or distribute more evenly on pasture.

Animal access to surface waters should be restricted. Providing shade and using insecticides can help reduce the need for animals to congregate in streams to obtain relief from heat and insects. It may be necessary to develop alternative sources of drinking water and restrict livestock access to the stream by fencing.

Summary

1. A basic principle in controlling animal waste pollution is to conserve the nutrients in manure and reuse (utilize) them to the maximum extent possible.

2. The primary control method is to reduce the availability of manure as a pollutant. This is accomplished by selecting the least critical site and using the proper rate, timing, and method of application. Storage will almost always be necessary to meet these objectives.

3. Detachment controls are effective only to the extent they control erosion of soil particles to which manure nutrients may be attached and, to a lesser extent, the erosion of manure particles themselves.

4. Manure pollutants can be controlled to a limited extent in the transport stage. If filter areas are used, manure particles and manure nutrients attached to sediment will be trapped.

5. Soil and water conservation practices are most effective when manure is surface applied and physically incorporated.

TABLES (Pm-1164 Extension Publication)

Table 1. Amount of fresh manure produced by mature farm animals.[1]

Kind of animal	Daily pounds	Annually tons	Water Content Percent
Beef[2]	60	11	88
Dairy[2]	82	15	87
Hogs	6	1.7	91

[1] Influenced by age and size of animal, ration, and other factors. [2] Based on 1,000 lb animals.

Table 2. Suggested average N, P_2O_5, and K_2O contents for barnyard manure in the year applied.

	Nutrient, lbs/ton		
Kind of Manure	N	P_2O_5	K_2O
Cattle or Hog	5	5	10
Dairy, fresh gutter	10	5	10
Dairy, stacked	12	7	12

Table 3. Suggested average N, P_2O_5, K_2O contents for liquid manure from confinement systems.

Source	Nutrients, lb/1,000 gal.		
	N	P_2O_5	K_2O
Beef or dairy without parlor wastes	45	21	31
Dairy with parlor wastes	23	11	23
Swine, finishing unit	55	27	34
Swine, farrow-nursery	30	10	10
Open feedlot runoff, beef	2	1	3

ACT-MAN-2

LIVESTOCK WASTE MANAGEMENT PLAN

Divide participants into groups to apply principles that have been discussed; and using INFO-MAN-3 and the soil survey report, develop recommendations for a livestock waste management plan for a local farm.

Select a farm with variable soils and with a pond or a stream on the farm or in the watershed. Locate a feedlot for 100 head of feeder cattle. Determine how you will temporarily store the manure; how you will prevent surface and groundwater pollution; and how and where you will apply the manure to an appropriate field or fields.

Answer the following questions:

1. Are there any direct paths for potential groundwater contamination?

2. What time of year will you apply manure to fields?

3. Is your feedlot located on soils that make it easier for pollutants to reach groundwater?

4. Would your plan conserve energy?

5. If after calculating your yield goal, you find that you need to add 50 lbs of nitrogen per acre to your cropland by manure application. How many acres could be fertilized with the manure from your 100 feeder cattle?

All the background needed to answer these questions is contained in INFO-MAN-3.

LIVESTOCK WASTE MANAGEMENT PLAN

Divide participants into groups to apply principles that have been discussed; and using INFO-MAN-3 and the soil survey report, develop recommendations for a livestock waste management plan for a local farm.

Select a farm with variable soils and with a pond or a stream on the farm or in the watershed. Locate a feedlot for 100 head of feeder cattle. Determine how you will temporarily store the manure; how you will prevent surface and groundwater pollution; and how and where you will apply the manure to an appropriate field or fields.

Answer the following questions:

1. Are there any direct paths for potential groundwater contamination?

   Direct paths include agricultural drainage wells, sinkholes, and unplugged abandoned wells.

2. What time of year will you apply manure to fields?

   Time of application should coincide as nearly as possible to crop needs and timed to coincide with tillage operations. Manure should not be spread on frozen or snow covered soil because of the potential loss to erosive forces. Fall application increases the potential for nitrogen loss through leaching.

3. Is your feedlot located on soils that make it easier for pollutants to reach groundwater?

   Coarse textured soils, sloping soils, excessively well drained as well as very poorly drained soils and impermeable soils are some soil characteristics that may contribute to groundwater pollution by point or non-point sources.

4. Would your plan conserve energy?

   Energy conservation would be influenced by the method of collection and storage as they affect nutrient analysis. Without proper storage and handling, the energy savings caused by the application of manure to fields is severely reduced.

5. If after calculating your yield goal, you find that you need to add 50 lbs of nitrogen per acre to your cropland by manure application. How many acres could be fertilized with the manure from your 100 feeder cattle operation?

   With proper storage and handling of barnyard manure, 100 feeder cattle could produce 1100 tons of manure annually. There are 5 pounds of nitrogen /ton of manure. So 100 feeder cattle could produce 5500 pounds of nitrogen annually or enough nitrogen to apply 50 pounds to 110 acres.

All the background needed to answer these questions is contained in INFO-MAN-3.

Laboratories That Offer Manure Analysis*

Following is a list of some private laboratories that will test animal manure for fertilizer value. This list, complied by Jim Kapp, Extension Soil, Water, and Waste Management Specialist, Iowa State University, Dubuque Area Office, is not intended to be a complete listing and no endorsement is intended.

Minnesota Valley Testing Laboratories, 35 West Lincoln Way, Nevada, Iowa 50201 515/3[illegible]-5486.

Iowa Testing Laboratories, Highway 17 North, Eagle Grove, Iowa 50533 515/448-4741.

Woodson Tenet Laboratories, 3507 Delaware Avenue, P.O. Box 1292, Des Moines, Iowa 50305 515/265-1461.

Harris Laboratories, Inc., 624 Peach Street, Box 80837, Lincoln, Nebraska 68501.

A & L Midwest Ag Laboratory, 11902 Elm Street, Omaha, Nebraska 68144.

Corning Testing Laboratories, 1922 Main, Cedar Falls, Iowa 50613 319/277-2401.

University of Wisconsin, Soils Department, Route #2, Marshfield, Wisconsin 54449.

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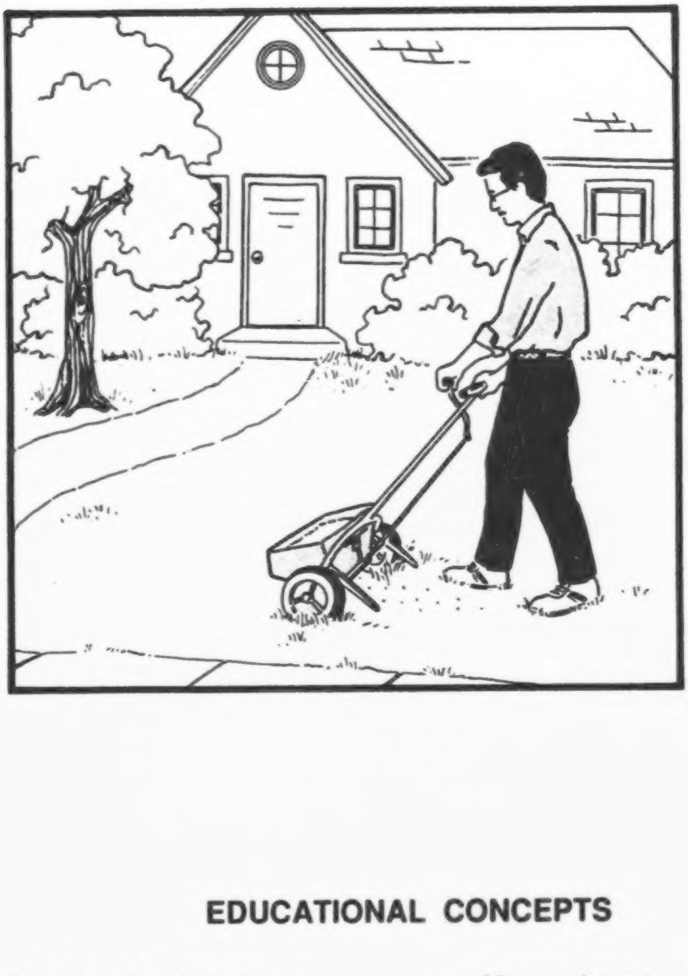
* Pm - 1164, Animal Manure: A Source of Crop Nutrients, Prepared by Randy Killorn, Extension Agronomist, Iowa State University, Ames, Iowa 50011.

MANAGING URBAN FERTILIZERS AND PESTICIDES



EDUCATIONAL CONCEPTS

- Similarities to agricultural use
- Differences from agricultural use
- Alternatives to urban use
- Energy conservation

Managing Urban Fertilizers and Pesticides

LESSON: Reducing Urban Contributions to Groundwater Contamination

GOAL:

It is important that we recognize urban contributions to groundwater contamination from fertilizers and pesticides to understand the relative relationship to agriculture and learn to reduce groundwater pollution through urban sources.

OBJECTIVES:

Upon completion of this lesson the participants will be able to:

1. Compare urban usage of fertilizers and pesticides with agricultural usage and the relationship to groundwater quality.

2. Describe safe disposal practices of fertilizers and pesticides and their containers.

3. Devise alternative pest management practices for lawn and garden care, resulting in energy conservation and reducing potential for groundwater contamination.

MATERIALS:

Overhead Projector
Journal of Freshwater

VISUAL MASTERS:

VM-URBAN-1 Rural-Urban Graph

ACTIVITIES:

ACT-URBAN-1 Urban Policy
POST-TEST & Key Conservation Planning Exercise.

INFORMATION:

INFO-URBAN-1	Residential Use of Pesticides and Fertilizers
INFO-URBAN-2	Advantages and Disadvantages
INFO-URBAN-3	Urban Map
INFO-URBAN-4	Hazardous Products
INFO-URBAN-5	Alternatives to Using Fertilizers and Pesticides
INFO-URBAN-6	Usage, Handling and Disposal of Fertilizers and Pesticides

INTEREST APPROACH:

Review INFO-URBAN-1 prior to beginning this lesson. Ask the questions on INFO-URBAN-1 (Answers: 1. 50 times greater, 2. Similar, 3. Farmer - Certified as private pesticide applicator for restricted use chemicals. Homeowner - none required, commerical applicator (such as lawn, garden companies and custom farming) certification is more difficult; a test must be taken for each recertification and for each type of chemicals they apply. Use VM-URBAN-1 to summarize.

TEACHING PROCEDURES:

1. Divide the participants into two groups. Allow one group to brainstorm advantages of using fertilizers and pesticides in urban areas. Allow the other group to brainstorm disadvantages of using fertilizers and pesticides in urban areas. Use INFO-URBAN-2 to summarize.

2. Use INFO-URBAN-3 in asking questions.

Prepared by Thomas Lewis, Department of Agricultural Education, Iowa State University, Ames, Iowa, June 1989.

    1. (Answer: Contaminants reach surface water through storm sewers from runoff water (lawns, gardens and parks to streets to the storm sewer then to rivers, lakes, etc). The contaminants reach groundwater by seeping through the soil into aquifers).

    2. Answers: A) 43' x 100' = 4,300 sq. ft./1,000 = 4.3 x 2 = 8.6 pounds of nitrogen are needed for your lawn, B) There are 43,560 sq. ft. in one acre, 43,560 sq. ft./1,000 = 43.6 x 2 = 87.2 pounds of nitrogen (per acre rate).

3. Direct a discussion on pesticides commonly found in the urban home. Make a list on the chalkboard. Discuss how these materials should be properly used, handled and disposed of. Use INFO-URBAN-4 to provide details on hazardous products.

4. As concerned citizens, we are aware of recent problems concerning our groundwater. We should always look for techniques to rid ourselves of those problems. With this in mind, direct the participants in identifying alternatives to using fertilizers and pesticides in urban areas. Use pages 30-32 of the Journal of Freshwater as a reference. Emphasize key points using INFO-URBAN-5.

5. Divide participants into groups and have them discuss proper techniques of using, handling and disposing of fertilizers and pesticides. Use INFO-URBAN-6 as a discussion guide.

6. Involve students in a simulated decision-making situation of setting city policy using ACT-URBAN-1.

ADDITIONAL ACTIVITIES:

1. Describe or explain that before one can become a pesticide applicator on agricultural land, he/she must meet certain requirements. The applicator must be registered through the Iowa Department of Agriculture. Applicators must also go through special training sessions in the application and handling of pesticides. Should this training be required for an urban dweller?

POST-TEST TO GROUNDWATER QUALITY CURRICULUM :

Use POST-TEST to evaluate participant's comprehension of the curriculum. Use the same teams of 2 or 3 used in the pre-test and evaluate highest team scores. Compare results of pre-test and post-test. Use POST-TEST KEY for a partial list of answers.

INFO-URBAN-1

RESIDENTIAL USE
OF PESTICIDES AND FERTILIZERS

Concentrations of pesticides and nitrates have been increasing steadily in Iowa's groundwater in recent years. Concerns over the potential adverse impact on human health due to this contamination has increased as well. One potential source of these contaminants may be their use in the urban environment.

Urban use of fertilizers and pesticides account for only 2% of the total use in Iowa. The other 98% of the chemicals are used for agriculture. Application rates for lawns are similar to rates for corn and soybeans.

The impact on public health from long-term exposure to water contaminated with pesticides and nitrates is not fully understood. There is an association between exposure to pesticides and increased cancer rates. There is also growing concern over the health impacts of exposure to nitrates. However, the greatest risk in urban areas may be due to direct contact, for example children playing on lawns.

Any pesticides sold in Iowa must be registered with the Iowa Department of Agriculture and Land Stewardship and the U.S. Environmental Protection Agency.

There are no regulations governing applications of pesticides or fertilizers registered for general use by urban residents. Though encouraged to follow label directions, there are no rules requiring training or certification. Urban residents are prohibited from buying restricted use pesticides unless they are registered applicators.

Professional pesticide applicators are required to be registered by the Iowa Department of Agriculture and Land Stewardship. This registration requires special training in the application and handling of pesticides.

Questions

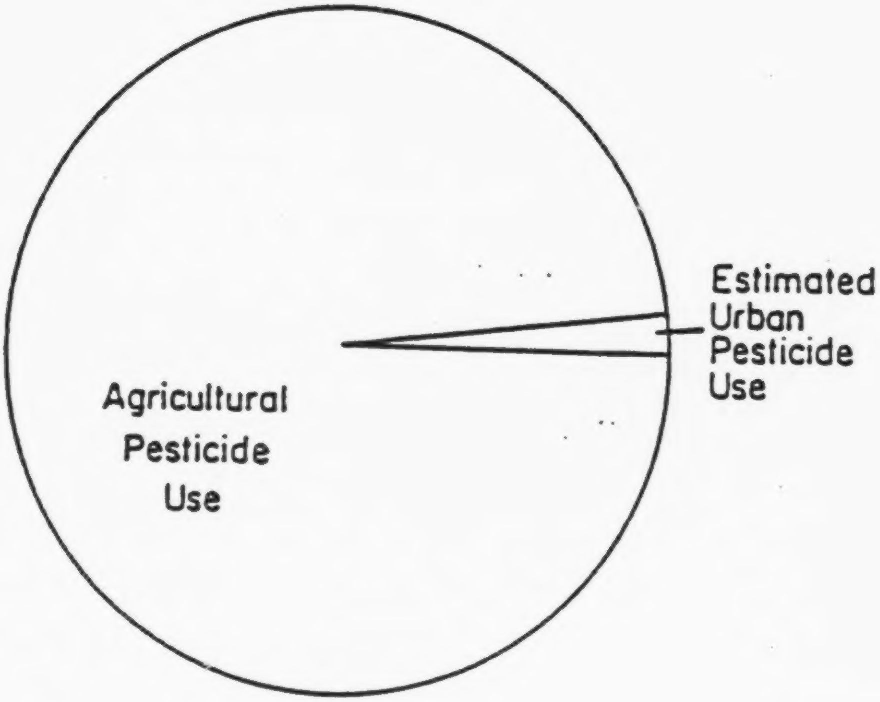
1. Is the total amount of pesticides applied in rural areas, less than or greater than in urban areas?

2. Is the rate of application of pesticides greater in rural areas or urban areas?

3. How does the certification for pesticide application compare for urban and agricultural areas?

Source: Iowa Groundwater Protection Strategy: 1987, pages 23 and 24

Comparison of Urban and Agricultural Pesticide Usage in Iowa



Source: Pimintel and Padgitt Personal Communications

ADVANTAGES OF USING FERTILIZERS AND PESTICIDES

If used correctly, fertilizers can:

1. add or supply the plant and soil with valuable nutrients
2. promote extra plant growth
3. increase crop productivity
4. improve crop quality

If used correctly, pesticides can:

1. control nuisance animals and insects
2. control plant diseases
3. protect against damage to lawns and gardens
4. aid in the cultivation of large scale single species plantings (monocultures) which produce large crop yields

DISADVANTAGES OF USING FERTILIZERS AND PESTICIDES

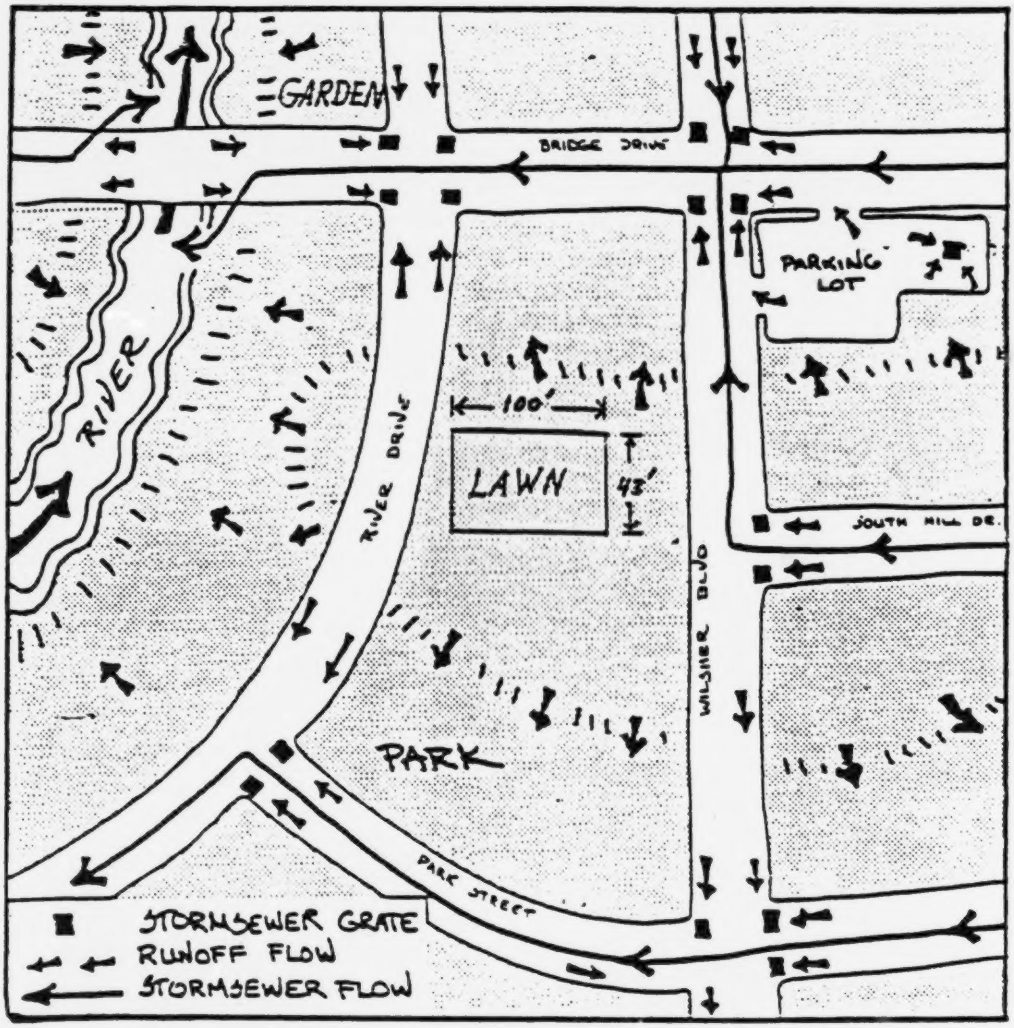
If not used correctly, fertilizers can:

1. damage grass, fruits and vegetables
2. increase the cost of water treatment
3. cause the death of fish and wildlife
4. present some danger to humans or consumers who work with them

If not used correctly, pesticides can:

1. affect target as well as nontarget species of plants and animals
2. cause pests or insects to become resistant to the chemical
3. cause danger to the consumers using them and to children and pets on lawns where sprays have not dried thoroughly
4. cause danger to animals in the food chain which consume grass and plants to which pesticides were applied
5. waste resources and energy (more pesticides need to be manufactured and transported)

URBAN MAP


GARDEN
BRIDGE DRIVE
PARKING LOT
RIVER
RIVER DRIVE
100'
LAWN
43'
SOUTH HILL DR.
WILSHER BLVD
PARK
PARK STREET
■ STORMSEWER GRATE
← ← RUNOFF FLOW
⟵ STORMSEWER FLOW

Adapted from "Local Watershed Problems Studies", Cooperative Educational Service Agency, Waukesha, Wisc. and Washington County Project, Water Resources Center, Madison, Wisc.

1. Where do contaminants enter surface and groundwater?

2. Your lawn as illustrated above is 100' in depth and 43' wide. Your soil test indicates you should apply 2 pounds of nitrogen per 1,000 sq. ft. area.
    a. How many total pounds of nitrogen are needed for your lawn?
    b. If you applied this same amount of nitrogen on cropland, at what per acre rate would you be applying nitrogen?

KINDS OF WASTES CONSIDERED TO BE HAZARDOUS

PRODUCTS IN THIS CATEGORY INCLUDE :

PESTICIDES INSECT SPRAYS WEED KILLERS

TOXIC EFFECTS : All pesticides and herbicides are designed to kill specific pests . They are also poisonous to people , pets and wildlife .

SPECIAL WARNING : The following pesticides are now banned from sale or severely restricted in use :

DDT
DBCP
Mirex
Aldrin
Heptachlor
Silvex
Dieldrin
Lindane
2,4,5-T
Chlordane
Kepone
Toxaphene

USE : Consider alternatives to pesticides whenever possible. Do not over-water . Pesticides and fertilizers can run off with the excess water into nearby storm drains or waterways .

DISPOSAL : Never dump into street sewers , storm drains or septic tanks.

GENERAL TIPS ON HAZARDOUS PRODUCTS

USE :

- Read the label and follow directions.
- Keep unused products in their original containers . The correct label provides directions for use and proper poison treatment .
- Always store in a safe place .
- Buy only what you need .
- Use the exact amount specified; twice as much does not mean twice the results.

DISPOSAL :

- Find a friend , neighbor , or business who can use up excess products for their intended purpose .

Source: Home Sweet Hazards. Iowa Department of Natural Resources

ALTERNATIVES TO USING FERTILIZERS AND PESTICIDES

* Use mulches and/or plastics to prevent weeds

* Use warm soapy water to wash off insects

* Handpick pests off plants

* Seal cracks and crevices with caulking to prevent pests from entering the home

* If cockroaches are a problem, try using small amounts of boric acid. Most cockroaches are resistant to pesticides

* Try hoeing or handweeding

* When mowing lawn, leave clippings on the grass as this adds nutrients to the soil

* Practice good sanitation - eliminates need for pesticides

* Choose better, hardy hybrids and varieties

* Use insect traps and lures

* Use least toxic but suitable pesticides

Source: Journal of Freshwater. Pages 30 - 32

USAGE, HANDLING AND DISPOSAL OF FERTILIZERS AND PESTICIDES

When using and handling fertilizers and pesticides:

* always read and follow label directions

* wear protective clothing (gloves, dust masks)

* avoid contact with skin

* use only what you need

* avoid using near water sources

* prevent substances from leaking out of containers

When disposing of fertilizers and pesticides:

* never dump into street sewers, drains or septic tanks

* find a friend or neighbor who can use up your excess

* when storing, keep products in original containers

* store in a safe place - away from children and animals

* take excess products to a special recycling facility

* do not discard; hold until hazardous waste collection day

* return excess to the manufacturer

* rinse empty containers with water, wrap container in plastic or newspaper and dispose of with household garbage

Source: Home Sweet Hazards: Iowa Department of Natural Resources. Disposal of Household Hazardous Waste. Cornell Cooperative Extension, New York State College of Human Ecology

URBAN POLICY

A DECISION-MAKING SIMULATION

Objectives

Participants will examine their own beliefs related to safe handling, use and disposal of fertilizer and pesticides and apply the process of committee decision-making skills.

Method

Through role-playing, participants read, discuss and analyze the processes involved in making decisions arriving at city policy in providing for safe handling, using and disposing of fertilizer and pesticides within the city limits.

Background

This simulation is designed to involve participants in a decision-making process, concerning the development of a city policy, to help insure water quality. You are members of the City Council. You need to weigh the issues on whether you (1) develop a city ordinance to regulate enforcement of rules and regulations (2) develop a major educational campaign on the water quality issues to educate the people in your city (3) provide financial incentives to stimulate voluntary compliance or (4) a combination of the above. The important issues and points of each of the above issues need to be spelled out to arrive at a meaningful council decision.

Procedure

1. Have individual participants or groups choose their roles, including one to play the part of the mayor.

2. Allow participants a day or two to prepare their statements and to conduct any research they feel necessary before presenting their positions. They may want to consult their parents.

3. Three individuals or three groups should choose their position, (one of the following four) to research and develop their recommendations:

   Individual or Group

   A. A city ordinance should be developed to enforce regulations on the citizens to insure proper handling, use and disposal of fertilizer and insecticide.

   B. Accomplish the objective through a major educational campaign.

   C. Accomplish the objective through an incentive program (you should develop a budget on the money needed for incentives).

   D. Accomplish the objective through a combination of the above.

   (Each of the four should develop their indivdual position including being able to answer the what, why and how they think their position is the best.)

4. In working groups, ask each group to choose a spokesperson to present its points to the council.

5. The mayor should begin the meeting by explaining the issue and restating the alternatives and then call on the spokespersons to make their presentations.

6. After each presentation, the mayor or other members of the City Council should be allowed to ask questions of the group.

7. Allow about 10 minutes for discussion and rebuttal after all statements have been heard.

8. Use proper parliamentary procedure in establishing a City Council policy statement.

9. Conclude by discussing the following with the participants:

   A. What difficulties did you encounter in arriving at your position?

   B. What additional information would have been helpful in reaching a decision?

   C. Did your personal interest have influence in the Council's final decision?

   D. Were there other factors that the City Council should have considered in arriving at their policy statement?

   E. Would the policy statement arrived at by the City Council be appropriate for your community and why or why not?

   F. Could you develop a project in your community similar to your simulated policy?

Conservation Planning Exercise

Situation

You are the owner of 320 acres (see scaled map) and a house in town. You have met with your county Soil Conservationist and together you have prepared a conservation plan for your farm. This plan accomplishes two purposes: (1) to control erosion and (2) to remain eligible for the 1985 Food Security Act.

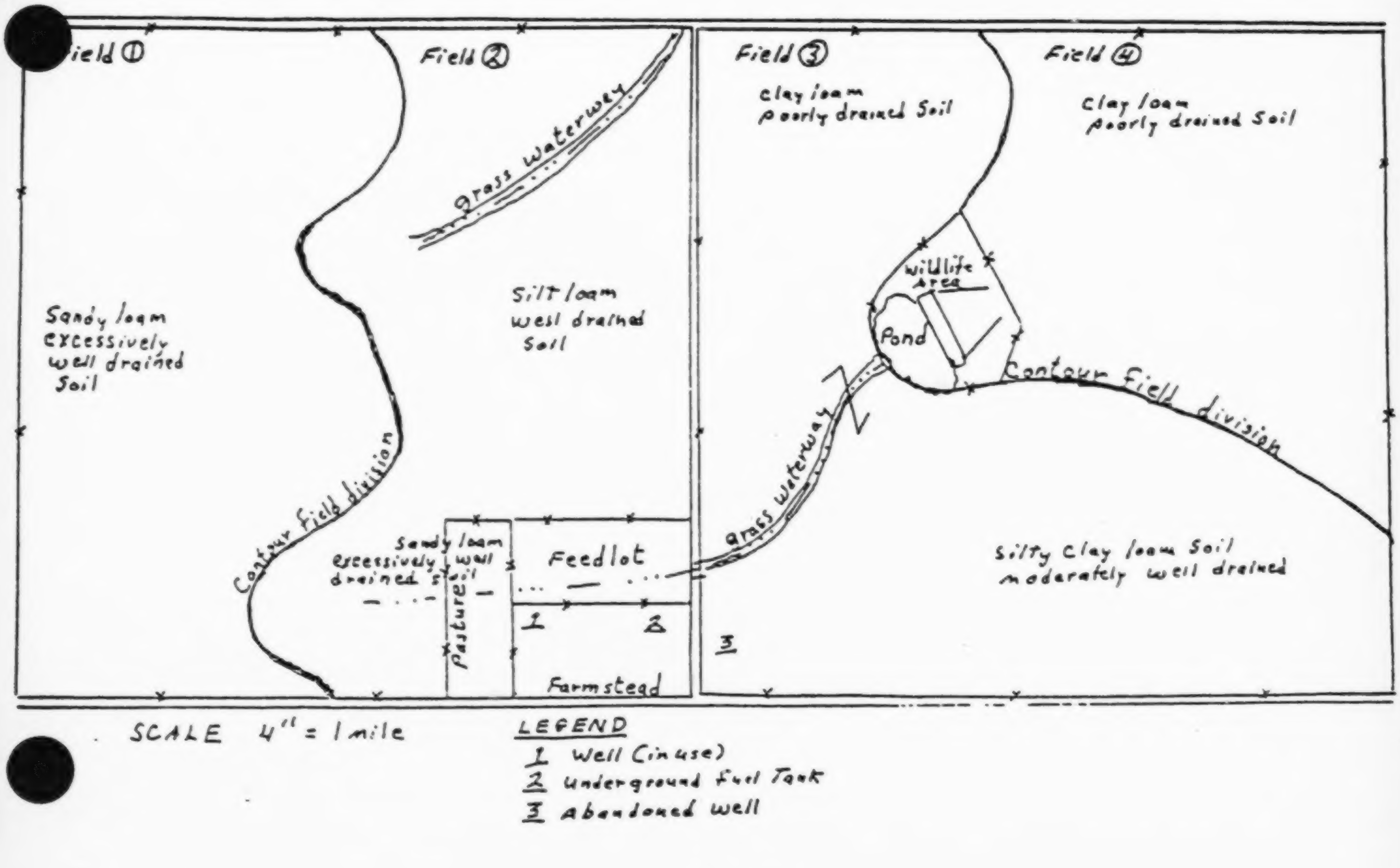
In addition, you feed 100 head of cattle each year and spread their manure on a small pasture located next to the feedlot. This pasture is on a sandy soil which is excessively well drained. Gasoline is stored in an underground tank (over 20 years old) as a safety precaution. The well you use for your on-farm household is located close to the feedlot and pasture. There is also an abandoned well on your farm, as well as a pond and wildlife area downstream from the feedlot.

You grow continuous corn and you apply an ample amount of pesticides (broadcast) because you don't want to take the risk of insect or weed problems. The use of a cultivator to control weeds is seldom used.

The county soil survey report shows that the soils on your farm have an average annual yield potential of 100 bu. of corn/acre under good management. You apply nitrogen each year at a rate estimated to produce 150 bushels of corn/acre. Fertilizer is purchased and applied (broadcast) in the fall to take advantage of lower costs.

You are following your conservation plan using practices such as contouring and conservation tillage to control erosion on gently sloping land. You have become concerned about how your farming operations may be adding to water pollution, and you want to revise your conservation plan using energy conservation and cost effective farming systems to reduce water pollution.

Furthermore, you suspect you have been using an excessive amount of lawn and garden chemicals on your property in town and feel you have been somewhat careless in the handling of these materials. You want to improve your management of lawn and garden pests to reduce the water pollution potential.


ield ①
Field ②
Field ③
Field ④
Grass waterway
Clay loam poorly drained Soil
Clay loam poorly drained Soil
Sandy loam excessively well drained Soil
Silt loam well drained Soil
Wildlife Area
Pond
Contour field division
Contour field division
Grass waterway
Sandy loam excessively well drained soil
Pasture
Feedlot
1
2
3
Farmstead
Silty clay loam Soil moderately well drained
SCALE 4" = 1 mile
LEGEND
1 Well (in use)
2 Underground fuel Tank
3 Abandoned well

To broaden your erosion control conservation plan to a sustainable agriculture, and energy conservation, faming system complete the following:

Assignment #1 : Analyze your farming operations to determine potential water pollution problems. Make a list of the problems which you think need to be corrected.

Assignment #2 : What management practices will you use to eliminate the potential water quality problems which you have identified?

Assignment #3 : Develop a cropping schedule on how you would convert from a continous corn cropping system to a sustainable agriculture system, using reduced pesticides and synthetic nitrogen. What crops would you grow in each field in 1990, 1991, 1992, 1993, maintaining approximately the same acreage of each crop each year?

	1989	1990	1991	1992	1993
Field 1	Corn				
Field 2	Corn				
Field 3	Corn				
Field 4	Corn				

Assignment #4 : How would the practices outlined above conserve energy (petroleum products)?

Assignment #5 : How do you plan to reduce chemical use and improve safety on your lawn and garden in town?

KEY POST-TEST

CONSERVATION PLANNING EXERCISE

Assignment #1 : Analyze your farming operations to determine potential water pollution problems. Make a list of the problems which you think need to be corrected.

1. Contamination of pond water and groundwater by manure - feedlot close to well, and in drainage area of pond; manure applied to pasture with sandy soil with potential leaching to groundwater.
2. The underground fuel tank (potential leaking) is located close to the well with potential leaching to groundwater.
3. The abandoned well could be a direct route of contamination from surface water to groundwater.
4. Excess pesticide is applied (not based on need).
5. Excess nitrogen is applied regardless of yield goal and it's broadcast in the fall when the crop won't utilize it (which will increase leaching potential and the surface runoff potential).
6. Nitrogen and pesticides are broadcast requiring use of an excess amount of chemicals which also increases overall energy use in manufacturing and transportation.
7. Continuous corn is grown increasing probability of pests and diseases.
8. Manure and legumes are not used, increasing the need for commercial nitrogen to provide crop nutrients.
9. There is concern about leaching of nitrates and pesticides in Field 1 because of excessively well drained soils, however, the heavier, finer textured soils in Fields 3 and 4 could develop more cracks in the dry periods of the year. This will result in potentially increased surface water moving through cracks to contaminate groundwater.

Assignment #2 : What management practices will you use to eliminate the potential water quality problems which you have identified?

1. The well water will be tested. If tests show contamination of disease-causing bacteria or nitrates, first check the well to be sure it is sealed correctly around the top to prevent run-in, also consider moving the feedlot or the well. Apply manure to the southeast portion of Field 3 rather than to the pasture, which contains excessively well drained soil. Manure will not be applied to frozen ground in order to reduce runoff potential, a manure storage facility and a diversion system will be constructed below the feedlot in Field 3 to store manure and to divert runoff outside of the pond drainage area.
2. The fuel tank will be excavated and replaced with an above ground tank.
3. The abandoned well will be plugged.
4. Pesticides will only be used when insect damage will exceed pesticide application costs and when they are applied they will use banding, incorporation, or on the row rather than the broadcast method. Sprayers will be calibrated to insure uniform application at the proper rates. Cultivation will be used to eliminate weeds between rows if weeds are a problem.

5. Yield goals will be established using the county soil survey. For this problem the yield goals average 100 bushels per acre for the farm. Each field, containing different soil types, will have different yield goals. Each field will be calculated individually. After computing the nitrogen contribution of the manure to be spread and the legume crop to be grown, synthetic nitrogen will be banded and incorporated on the row in the amount sufficient for producing the yield goal in each field.

Assignment #3: Develop a cropping schedule on how you would convert from a continous corn cropping system to a sustainable agriculture system, using reduced pesticides and synthetic nitrogen. What crops would you grow in each field in 1990, 1991, 1992, 1993, maintaining approximately the same acreage of each crop each year?

Following is one example of a cropping system schedule (corn, soybeans, corn, green manure rotation) chosen to convert to a sustainable agriculture system.

	1989	1990	1991	1992	1993
FIELD 1	CORN	OATS/GM	CORN	SOYBEANS	CORN
FIELD 2	CORN	CORN	OATS/GM	CORN	SOYBEANS
FIELD 3	CORN	SOYBEANS	CORN	OATS/GM	CORN
FIELD 4	CORN	CORN	SOYBEANS	CORN	OATS/GM

*GM= Green-manure

Assignment #4 : How would the practices outlined above conserve energy (petroleum products), time, or redistribute labor needs?

Reducing fertilizers and pesticides to only what is needed for the plants and finding alternative sources, reduces the energy used in the manufacturing of, and the transporting of petroleum products. Substituting an oat/green manure rotation for continuous corn spreads some labor needed for corn planting to oat harvest and hay or forage harvesting, thus distributing labor requirements more evenly throughout the year.

Assignment #5 : How do you plan to reduce chemical use and improve safety on your lawn and garden in town?

I will reduce chemical use and improve safety on my lawn and garden as follows:

1. I will read and follow the labels and calculate only what is needed based on the square footage.
2. I will apply pesticides only when there is an insect problem. I'll hand weed my garden rather than use a herbicide.
3. I will properly dispose of unused chemicals, such as, rinsing empty containers with water, wrapping container in plastic or newspaper and disposing of with household garbage.
4. I'll compost my food and lawn waste to use for fertilizer.

CAREERS

CAREERS

CAREERS USING GROUNDWATER COMPETENCIES

Listed below are some careers where people may use groundwater knowledges and skills in their work:

Farmer
Geologist
Soil Conservationist
Soil Scientist
Chemist
Biologist
Sales Person
Extension Director
Design Engineer
Agriculture Teacher
Forestor
Water District Manager
Pesticide Dealer/Employee
Implement Dealer/Employee
Extension Home Economist
Biogeneticist
Extension Agriculturist
Farm Manager

Gardener
Researcher
Agronomist
Land Use or Management Planner
Policy Maker
Geneticist
Genetic Engineer
Lawn Care Specialist
Water Specialist
Municipal Water Manager
Resource Conservationist
Laboratory Consultant
Fertilizer Dealer/Employee
Seed Dealer
Agricultural Consultant
Chemical Engineer
Pest Control Person

GLOSSARY

Glossary

Abandoned well: A well that has been permanently discontinued

Absorb: (Absorbsion) To take up or receive by chemical or molecular action, to soak in or take in like a sponge.

Acre-foot: The volume of water required to cover one acre of land (43,566 sq. ft.) to a depth of one foot; equivalent to 325,851 gallons.

Acute toxicity: Any poisonous effect produced within a short time usually up to 24 - 96 hours.

Adsorb: (Adsorbsion) To gather a gas, liquid, or dissolved substance on a surface (attracted to and adhere to solid mineral surface).

Aeration: Increasing oxygen content of a liquid by spraying the liquid into the air, or agitating the liquid to promote surface adsorption of air.

Aerobic bacteria: Bacteria that require free elemental oxygen for growth.

Agriculture drainage well: Wells installed in wetland to provide an outlet for drainage systems. The well connects the outlet of the drainage system (tile or surface outlet) directly with an aquifer.

Ammonium fixation: Tie up of ammonium form of nitrogen on to the clay structures in the soil.

Ammonium nitrogen: A colorless salt used in fertilizers.

Anaerobic bacteria: Bacteria not requiring the presence of free or dissolved oxygen for metabolism.

Aquatic life: Organisms growing or living in or on water.

Aquiclude: A material that stores water, but does not transmit significant amounts.

Aquifer: A sand, gravel, or rock formation capable of storing or conveying water below the surface of the land (capable of storing and transmitting significant volumes of water to a well or spring). Derived from Latin word meaning "water carrier".

Aquitard: A material that stores water, transmits enough to be important on a regional basis, but not enough to support individual wells.

Attenuation: The process by which the concentration of a pollutant or contaminant decreases or is removed from solution as it moves through soil and aquifer medium.

Available nutrient: That portion of any element or compound in the soil that can be readily absorbed and assimilated by growing plants.

Baseflow: The stream discharge composed of ground water drainage and delayed surface drainage.

Bed load: The sediment that moves by sliding, rolling, or bouncing on or near the streambed.

Bedrock: Unbroken solid rock, overlaid in most places by soil or rock fragments.

Biological control: A method of controlling pests by means of introducing or naturally occurring predatory organisms.

Blue-baby syndrome: Blood related condition found in babies due to nitrate poisoning.

Bored well: A well drilled with a large truck-mounted boring auger. Wells usually 12 inches in diameter or larger and cased with concrete seldom deeper than 100 feet.

Carcinogenic: Event, condition or effect that produces cancer.

Coliform bacteria: A group of bacteria that mostly inhabits the intestinal tract of humans and animals, but also found in soil. While harmless in themselves, coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms.

Condensation: The process by which a substance changes from the vapor state to the liquid state.

Cone of depression: A depression in the water table produced by the extraction of water from a well.

Confined aquifer: Aquifer in which groundwater is confined under a pressure which is significantly greater than atmospheric pressure.

Conservation tillage. A tillage system that does not invert the soil and that leaves a protective amount of residue on the surface throughout the year.

Contaminant: Any substance that makes water or soil unfit for use.

Contour stripcropping: Growing crops in strips that follow the contour. Strips of grass and legumes are alternated with strips of clean-tilled crops or summer fallow.

Crop residue: Residue (portions of annual plants) left on the soil surface following harvest for erosion control and water conservation purposes.

Crop root zone: The depth of soil penetrated by plant roots.

Decomposition: To undergo chemical breakdown, decay.

Deep percolation: The downward movement of water through the soil below the crop root zone.

Degradation: To wear down, reduce to lower quality, by erosion or reduce the complexity of a chemical compound.

Denitrification: The reduction of nitrates, with nitrogen gas evolved as an end product.

Disinfection: The process of killing living organisms through chemical or physical means. Chlorination is popular but not the only means.

Distillation: The process of evaporating a liquid, then recondensing it to purify it.

Diversion: A ridge of earth, generally built across the slope, to protect downslope areas by diverting runoff water from its natural course.

Drainage: (1) Removal of excess surface or ground water from land by surface or subsurface drains. (2) Soil characteristics that affect natural drainage.

Drilled well. Well drilled with a drilling rig. Usually 10 inches in diameter or less, cased with plastic or steel. Can be drilled into bedrock and can be shallow or deep.

Dug well. A large diameter well dug by hand. Usually old, often cased by concrete or hand-laid bricks, less than 50 feet and often are contaminated.

Economic threshold: The point at which the crop damage due to pests is economically feasible for a pesticide treatment. The expected gain from treatment is greater than the cost of treatment.

Effluent: The discharge of a pollutant, or pollutants, in a liquid form from a containing space.

Environment: The complex of physical, chemical and biotic factors as climate, soil and living things that act upon an organism.

Ephemeral: Lasting a very short time.

Ephemeral stream: A stream or portion of a stream that flows only in direct response to precipitation, and receives little or no water from springs or a continuous supply from snow or other sources. Its channel is at all times above the water table. See intermittent stream.

Eutrophication: The natural or artificial process of nutrient enrichment whereby a water body becomes filled with aquatic plants and low in oxygen content, which is detrimental to fish.

Eutrophic lake: A lake that has a high level of plant nutrients, a high level of biological productivity, and low oxygen content.

Evaporation: The process by which water passes from liquid to vapor phase.

Evapotranspiration: The loss of water from an area by evaporation from the soil and plant surfaces and by transpiration from plants.

FOTG: Field Office Technical Guide. FOTG's are primarily technical references for SCS. They contain technical information about conservation of soil, water, and related plant and animal resources. Technical guides are localized so that they specifically apply to the geographic area in which they are used.

Field capacity; field moisture capacity: The moisture content of a soil, expressed as a percentage of the ovendry weight, after it has been thoroughly soaked and allowed to drain freely; the field moisture content 2 or 3 days after a soaking rain.

Filter strip: A strip or area of vegetation which slows runoff or wastewater, allowing sediment, organic matter, and other pollutants to settle out from the flow.

Food chain: The interdependence of living organisms, plants and animals.

Geology: The science that deals with solid matter and history of the earth.

Glacial till: Unsorted deposits by a glacier which are composed of materials of all sizes from clays to boulders.

Grassed waterway: A natural or constructed waterway, typically broad and shallow, seeded to erosion-resistant grasses, used to conduct surface water from or through cropland, at a nonerosive rate of flow.

Groundwater: The subsurface water supply in the saturated zone below the level of the water table.

Gully: A channel resulting from erosion and caused by the concentrated flow of water during or immediately following heavy rains. A gully generally is an obstacle to farm machinery and is too deep to be eliminated by ordinary tillage. (A rill is of lesser depth and can be smoothed by ordinary tillage.)

Half life: The time it takes certain materials, such as persistent pesticides or radio active materials to lose half their strength - example: DDT half life is 15 years, radium is 580 years.

Hazardous waste: Waste, which because of its quantity, concentration, or physical, chemical or infectious characteristics may cause mortality or an increase in serious illness.

Heavy metals: Metallic elements like mercury, arsenic and lead - generally toxic in low concentrations to plants and animal life.

Herbicides: Chemicals used to kill undesirable vegetation.

Hydrologic cycle: The water cycle. The movement of water from the atmosphere to the earth and again to the atmosphere through condensation, precipitation, evaporation, transpiration, percolation, runoff and storage.

Hydrologic soil groups: Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of the soil bare of vegetation to permit infiltration. Soils are assigned to four groups; soils in Group A have a high infiltration rate when thoroughly wet and a low runoff potential; soils in Group D are at the opposite extreme.

Hydrology: Pertaining to the occurrence, circulation, distribution and properties of water on the earth and the earth's surface.

Impaired use: To diminish the value, quantity or quality for a specific purpose.

Infiltration: The downward entry of water into the soil. This is distinct from percolation, which is movement of water through soil layers or material.

Infiltration rate: The rate at which water outlets the soil or the porous material, under a given condition, expressed as depth of water per unit time, usually in inches (centimeters) per hour.

Insecticide: Chemicals used to control undesirable insects.

Integrated pest management (IPM): Reducing the amount of pesticides through a management program aimed at timely application and efficient use.

Interflow: That portion of rainfall that infiltrates into the soil and moves laterally through the upper soil horizons until intercepted by a stream channel or until it returns to the surface at some point downslope from its point of infiltration.

Intermittent stream: A stream or portion of a stream that is dry for a large part of the year, ordinarily more than 3 months. See ephemeral stream.

Irrigation efficiency: The amount of water stored in the crop root zone compared with the amount of irrigation water applied.

Irrigation return flow: Surface and subsurface water which leaves the field following the application of irrigation water.

Karst: Topography characterized by depressions without external drainage; sinkholes; underground caverns; solution channels. Land forms that have been formed by the solution and collapse of underlying carbonate (limestone) rocks.

Koc: A measurement of the index for soil sorption, or the tendency of pesticides to be attached, by chemical or physical bonds, to soil particle surfaces.

Lagoon: Water impoundment in which organic wastes are stored or stabilized or both.

Landfill: A disposal site in the land for waste materials.

Leachate: Liquids that have percolated through a soil and that carry substances in solution or suspension.

Leaching: Removal of soluble materials including salts and alkali from soils by a liquid through downward or lateral drainage or both.

Loess: A fine grained soil deposited by wind, having little or no stratification.

MCL: Maximum Contaminant Limit. The maximum level of specific contaminants that is allowed by law.

Mg/L: Milligrams per liter.

MLRA: See Major Land Resource Area.

Macropore: A pore or soil void, larger than about 0.075mm (e.g. worm holes, shrinkage cracks, root channels).

Major Land Resource Area: An area of land reasonably alike in its relationship to agriculture with emphasis on intensities of problems in soil and water conservation; ordinarily larger than a land resource unit and smaller than a land resource region.

Manure: The fecal and urinary defecation of livestock and poultry.

Mounding: A rise in water table elevation resulting from man's activities.

Nitrate ($\mathrm{N0\overline{3}}$): An important plant nutrient and type of inorganic fertilizer (most highly oxidized phase in the nitrogen cycle). In water, the major sources of nitrates are septic tanks, feed lots and fertilizers.

Nitrification: Two-step process of ammonium (NH+4) changing to nitrite ($\mathrm{No\overline{2}}$) then to nitrate (No3).

Nitrite: ($\mathrm{No\overline{2}}$) First product in the nitrification process in the conversion of ammonium to nitrate.

Nitrogen cycle: Continuous cycle where atmospheric nitrogen is compounded, dissolved in rain, deposited in the soil, processed by bacteria and plants, and returned to the atmosphere by organic decomposition.

Nitrogen-fixation: The conversion of elemental nitrogen from the atmosphere to organic combinations or to forms readily utilized in biological processes. Normally carried out by bacteria, living in legumes or by free-living soil bacteria.

Non point pollution: Pollution that cannot be traced to one source, but rather comes from many different, non-specific sources, such as runoff from cultivated fields, grazing land, or urban areas.

No till; zero till: Planting a crop without prior seedbed preparation into sod, crop residue, or an existing cover crop and eliminating subsequent tillage operations.

Nutrients: Fertilizer, particularly phosphorus and nitrogen--the two most common components that run off in sediment.

Organic matter: Chemical substances of animal or vegetable origin.

Overstocking: Placing a number of animals on a given area that will result in overuse of plant resources at the end of the planned grazing period, and placing an oversupply of fish in water in comparison to the oxygen and food supply.

Parts per million (PPM): A common basis for reporting water analysis. One part per million equals one pound per million pounds of water.

Pathogens: Disease-causing organisms.

Percolation: The flow of liquid downward through porous material.

Percolation rate: The rate of movement of water (under hydrostatic pressure) through porous materials (inches/hour).

Permeability: The capacity of a porous rock, sediment or soil for transmitting fluid. A measure of the relative ease of fluid flow under pressure.

Persistence time: The time required for a pesticide to become inert (inactive). Arbitrarily assumed to equal four half-lives when measured persistence time not available.

Pesticide: A chemical substance used to kill or control pests such as weeds, insects, fungus, mites, algae, rodents, and other undesirable agents.

Planner: The final responsibility for resource management planning decisions must be made by the individual who owns or controls the land, so he or she is the real "planner." In this material, however, "planner" refers to the agency representative or consultant assisting the land user. This avoids the use and repetition of long titles.

Point source pollution: Pollution arising from a well-defined origin, such as a discharge from an industrial plant or runoff from a beef cattle feedlot.

Pollution: The presence in a body of water (or soil or air) of material in such quantities that it impairs the water's usefulness or renders it offensive to the sense of sight, taste or smell.

Pollution plume: An area of a stream or aquifer containing degraded water resulting from migration of a pollutant.

Porosity: The percentage of total volume of a given material that is pore space.

Postemergence: Application of chemicals, fertilizers, or other materials along with the operations associated with crop production after the crop has emerged through the soil surface.

Potable water: Water that is safe and palatable for human use.

Precipitation: Rain, hail, mist, sleet or snow that falls to earth.

RCN: See Runoff Curve Number.

RMS: See Resource Management Systems.

Receiving waters: All distinct bodies of water that receive runoff such as streams, rivers, ponds, lakes, and estuaries. Also, all navigable surface waters and, in certain instances, ground water, if there is a direct connection.

Recharge: Replenishment of groundwater by infiltration of water through the soil. The process of addition of water to the zone of saturation.

Resource Management Systems (RMS): An RMS is a combination of conservation practices and management techniques identified by the primary use of the land or water. Under an RMS, the resource base is protected by meeting acceptable soil losses, maintaining acceptable water quality, and maintaining acceptable ecological and management levels for the selected area.

Reverse Osmosis: Treatment that uses a very fine molecular sieve that permits water to pass through it but not contaminants. Used for nitrate removal.

Root zone; rooting zone: The depth of soil penetrated by crop roots.

Runoff: That portion of precipitation or irrigation water that flows off a field and enters surface streams or water bodies. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground water seepage interflow.

Runoff curve number (RCN): The SCS procedure for estimating direct runoff. The RCN represents an index value that expresses the runoff potential from a watershed based on a combination of soils (hydrologic soil group) and a land use treatment class (cover). The runoff curve number shows the relative value of the hydrologic soil/cover complexes in producing direct runoff.

Safe yield: The amount of water that can be removed or withdrawn without the risk of interruption of water supply.

Saline seep: Area of recently developed salinity concentration on nonirrigated land where salty ground water moves to the surface and crop or grass production is reduced or eliminated.

Salinity: The concentration of dissolved salts in water.

Saturated zone: The part of a water-bearing formation in which all the void spaces are filled with water.

Sediment: The solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface.

Sediment yield: The quantity of sediment arriving at a specific location.

Seepage: Percolation of water through the soil from unlined canals, ditches, laterals, watercourses, or water storage facilities.

Septic tank: A settling tank in which organic solids are decomposed by anaerobic bacteria.

Series, soil: A group of soils that have profiles almost alike except texture.

Sinkhole: A depression in the landscape where limestone has been dissolved, allowing for a direct path of surface water to groundwater.

Sheet erosion: The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Sludge: The accumulated solids separated from liquids, such as water or wastewater during processing or deposits on bottoms of streams or other bodies of water.

Soil profile: A cross section of soil through which water must pass to reach the water table. Composed of different layers of soil, the profile is typically considered the top 5 feet but may be deeper.

Soil sorption index: The capability of chemicals to absorb into or adsorb to soil or organic particles; measured by the Koc value.

Sorb: To take up and hold either by absorption or adsorption.

Sorption: The binding of one substance to another either by absorption or adsorption.

Spring: A flow of groundwater emerging naturally at the surface of the ground.

Stage discharge: A relationship that provides water surface elevation (usually in feet) and the rate of low or discharge capacity (usually in cubic feet per second).

Stripcropping: Growing crops in alternating strips or bands that provide vegetative barriers to wind and water erosion.

Structure, soil: The arrangement of soil particles into aggregates.

Surface layer: The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches. Also called the plow layer.

Tailwater: The runoff of irrigated water from the lower end of an irrigated field, or the water on the upper reaches of impounded water, closest to the source of runoff water.

Terrace: An embankment or ridge constructed on the contour or at a slight angle to the contour across sloping soils. Runoff water intercepted by the terrace soaks into the soil or flows slowly to a prepared outlet.

Texture, soil: The relative amounts of sand, silt and clay in a given soil.

Tilth, soil: The physical condition of the soil affecting the soil's ease of tillage and fitness for plant growth.

Total dissolved solids: The total amount in milligrams of solid material dissolved in one liter of water (Mg/L).

Transpiration: The process by which water in living organisms, primarily plants, passes into the atmosphere.

Turbidity: The state, condition or quality of a reduced clarity of a fluid due to the presence of suspended matter.

USLE: Universal Soil Loss Equation: A method of estimating the average soil loss from sheet and rill erosion that might be expected to occur over an extended period of time under specified conditions of soils, slope, vegetation, climate, cultural operations, and conservation measures.

Unsaturated zone: The zone between the land surface and the water table in which some of the pore spaces are filled with air and some with water.

Volatization: Loss of a substance through evaporation or sublimation. When manure is spread on a field, ammonia-nitrogen in the manure may volatilize quickly and be lost as a fertilizer unless it is incorporated into the soil.

Water budget: The relationship, or equation, which describes the balance and movement of water within soil, plants, and atmosphere.

Watershed: All the land surface from which water drains into a common outlet.

Water table: The surface of groundwater or the level below which the soil is saturated with water.

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REFERENCE LIST

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APPENDIX

APPENDIX

Water Testing Laboratories

The primary laboratory for water testing in the state of Iowa is the University Hygienic Laboratory, University of Iowa, Oakdale Hospital, Iowa City, Iowa 52242, 319-335-4500.

There are a number of other labs. All testing labs certified to test for nitrates were contacted (Jan/88) and asked if they wished to be on a list for agriculture teachers who might wish to test water samples.

Be aware that labs which offer to test water at lower rates may be doing a simple screening test rather than a certified test.

Name: Mangold Environmental Testing, 1715 N. Lake Avenue, P.O. Box 1093, Storm Lake, Iowa 50588, 712-732-7786

Cost: $7 per nitrate sample
Reduced costs for quantities: above cost is quantity cost
Limits to service area: only the state of Iowa
Container procedures: may be obtained by contacting lab
Turn-around time: approximately three working days

Name: Siouxland District Health Department, 205 Fifth Street, Sioux City, Iowa 51101

Cost: $10, $3 nitrate prescreen
Reduced costs for quantities: none
Limits to service area: none
Container procedures: mailed by department, or use own
Turn-around time: 2 to 4 days

Name: A & L Mid West Agricultural Laboratories, 13611 "B" Street, Omaha, Nebraska 68144-3693, 402-334-7770

Cost: $15 per sample
Reduced costs for quantities: up to 25%
Limits to service area: none
Container procedures: prefer pre-cleaned containers, but can use own
Turn-around time: 10 days

Name: Marshalltown Water Works, Treatment Plant Superintendent, 1935 N. Center Street P.O. Box 1420, Marshalltown, Iowa 50158, 515-753-3997

Cost: $8 per sample, coliform only
Reduced costs for quantities: 10% after 10 samples
Limits to service area: none
Container procedures: containers from lab
Turn-around time: 72 hrs by phone

Name: Minnesota Valley Testing Laboratories, 35 Lincoln Way, Nevada, Iowa 50201 515-382-5486, 1-800-362-0855

Cost: $11 per sample
Reduced costs for quantities: none
Limits to service area: none as long as it can reach the lab in 48 hrs
Container procedures: bottle kits available from the lab
Turn-around time: 1 to 3 days

Name: La Mura Labs Inc., Suite 105, 1314 4th Street S.W., Mason City, Iowa 50401
515-424-9461

Cost: $9.45 per sample, coliform only
Reduced costs for quantities: 15%
Limits to service area: must be received within 48 hrs
Container procedures: sterile bottles provided on request
Turn-around time: 5 - 7 days

Name: Lindaman Labs, Jewell, Iowa 50130, 515-827-5669

Cost: $9 per sample
Reduced costs for quantities: bid price
Limits to service area: none
Container procedures: provided by lab
Turn-around time: 2 to 3 days

Name: San Labs, 405 Eighth Avenue S.E., Cedar Rapids, Iowa 52401, 319-366-3570

Cost: $23 per sample
Reduced costs for quantities: call for a quote
Limits to service area: send sample as soon as possible
Container procedures: a container rinsed several times with the water being sampled should be used
Turn-around time: samples tested as soon as received, reports sent upon test completion

Name: Northeast Iowa Water Laboratory, 101 E. Third St., Waterloo, Iowa 50703
319-235-4440

Cost: $14 per sample
Reduced costs for quantities: quantity reductions to $12
Limits to service area: any place in Iowa that can have the sample to the lab in 48 hrs.
Container procedures: vary according to need, can supply
Turn-around time: varies with situation, 5 to 7 days

Name: Keokuk Municipal Water Works, 20 N. 4th Street, P.O. Box 1265, Keokuk, Iowa 52632
319-524-5285

Cost: $15 per sample, coliform only
Reduced costs for quantities: none
Limits to service area: no limits
Container procedures: can be obtained from lab, samples accepted Monday thru Wednesday
Turn-around time: by phone-48 hrs, report 5 days

Name: Davenport Water Pollution Control Plant, 2606 South Concord Street, Davenport, Iowa 52802, 319-326-7877

Cost: $15 per sample
Reduced costs for quantities: none
Limits to service area: nitrate may be done by mail
Container procedures: not listed
Turn-around time: 1 to 3 weeks

Name: Serco Laboratories, 1922 Main Street, P.O. Box 625, Cedar Falls, Iowa 50613
319-277-2401

Cost: $10 per sample
Reduced costs for quantities: not stated
Limits to service area: throughout Iowa
Container procedures: provide sample containers upon request
Turn-around time: 2 weeks

Name: Dubuque County, Environmental Health Lab, Dubuque, Iowa

Cost: $7 per sample, coliform only
Reduced costs for quantities: not applicable
Limits to service area: mainly Dubuque County
Container procedures: glass containers or sterile bags
Turn-around time: 5 days

Name: City of Dubuque, Office of Public Works, City Hall, Dubuque, Iowa 52001
319-589-4269

Cost: $7.50 per sample
Reduced costs for quantities: 10% for five samples
Limits to service area: no limit but sample should not be over 24 hours old
Container procedures: provided by lab
Turn-around time: 1 week

Name: Davy Laboratories, 115 South Sixth Street, P.O. Box 2076, La Crosse, Wisconsin
54602-2076, 608-782-3130

Cost: $10 Nitrite + Nitrate, coliform only
Reduced costs for quantities: varies 10% to 50% depending on test and quantity
Limits to service area: anywhere in Iowa but dependent on test to be done
Container procedures: sample kits provided with no cost
Turn-around time: varies from 24 hrs to 4 days

THE GROUNDWATER ACT

How Does It Affect You?

General Provisions

- It significantly increases the amount of information collected by the state on the quality of groundwater.
- It establishes the Leopold Center at Iowa State University to study agricultural impacts on groundwater quality.
- It establishes an Environmental Health Center at the University of Iowa to assess pollution's impact on human health.
- It establishes a Small Business Center at the University of Northern Iowa to help small businesses properly handle and dispose of solid and hazardous materials.

Pesticides and Fertilizers

- Anyone engaged in the sale of fertilizers must obtain an annual license at the cost of $10 from the Department of Agriculture and Land Stewardship.
- Anyone selling specialty fertilizers in quantities of 25 lbs. or less or applying specialty fertilizers for compensation must pay an inspection fee of $50 annually.
- Anyone manufacturing specialty fertilizers in quantities of 25 lbs. or less must pay a registration and an inspection fee of $100 annually.
- Anyone selling nitrogen-based fertilizers must pay an additional $.75 per ton sold based on an 82 percent solution and prorated for different solutions.
- Commercial or public applicators applying any pesticide must be certified. Certified pesticide applicators must now pass a state exam.
- Any person applying a restricted-use pesticide must be certified.
- Anyone engaged in the sale of pesticides must obtain a $25 annual license from the Department of Agriculture with the exception of dealers whose gross annual sales are less than $10,000 for each business location owned or operated by the dealer. After July 1, 1988, the license will cost one-tenth of one percent of gross sales.
- In order to register a pesticide for use in Iowa, the manufacturer must pay a registration fee for each chemical in the amount of one-fifth of one percent of gross sales up to a maximum of $3,000.

Wells, Sinkholes, Watersheds and Wetlands

- All ag drainage wells must be registered with the DNR by January 1, 1988.
- The Department of Agriculture and Land Stewardship will set up a demonstration project to show what types of practices will eliminate groundwater contamination from ag drainage wells and sinkholes and also suggest alternative drainage methods.
- By 1991, all ag drainage well owners must submit a plan to the Department of Agriculture and Land Stewardship showing how contamination will be eliminated from their ag drainage well or wells.
- The state goal is to eliminate all contamination from ag drainage wells and sinkholes by 1995.
- All new well construction after July 1, 1987, can only be done after a permit has been obtained from the county or DNR.
- A schedule for closing of all abandoned wells will be established and a financial assistance program set up by the DNR.
- After July 1, 1987, upon the sale of any property, the landowner must disclose any waste disposal site, underground storage tank, or existing well on the property.

Solid Waste Management and Landfills

- The tonnage fee for disposal in landfills will increase after July 1, 1988, by $.50 per ton per year until it reaches $3.50 per ton. This may mean an increase in solid waste disposal rates charged to the customer by a municipality.
- Plans are being made for alternative disposal methods from tonnage fees.
- All sanitary landfill operators must be certified by the state by July 1, 1990.
- Private disposal of any waste on any property now requires a permit from the DNR.

Household Hazardous Wastes

- All retailers who sell household hazardous materials must now have a permit which costs from $10 to $100 depending upon gross sales. Permits are obtained from the Department of Revenue and Finance.
- Retailers will display shelf labels which identify products that are considered hazardous. Informational booklets will also be available which will explain how these materials are to be handled and disposed.
- Toxic Waste Cleanup Days will occur in at least six locations (and perhaps more) around the state where the public can dispose of household hazardous materials.

Underground Storage Tank Management

- New farm and residential underground storage tanks (put into service after July 1, 1987) with a capacity of less than 1,100 gallons must now be registered with DNR for a one-time fee of $10.
- Farm and residential tanks under 1,100 gallons existing prior to July 1, 1987, shall be reported to the DNR by July 1, 1989. No fee is required.
- All underground storage tanks over 1,100 gallons must be registered with the DNR and tagged annually for a management fee of $15.
- A legislative committee will make recommendations on establishing insurance pool to insure proper tank installation and removal of unused and leaking tanks.
- Unlawful to deliver product to untagged tanks.

DNR

IOWA DEPARTMENT OF NATURAL RESOURCES
Wallace State Office Building
Des Moines, Iowa 50319

Reprinted from the *Iowa* CONSERVATIONIST, August 1987.

VIDEOS RELATED TO GROUNDWATER

Media Resources Center
Iowa State University
121 Pearson Hall
Ames, Iowa 50011
515/294-1540

CATALOG NUMBER/LENGTH TITLE
69070H 57 Min. DOWN ON THE FARM - 1984

A program about environmental problems related to agriculture. Provides illustrations of various ecological methods for farming practices. (NOVA Series.) The video, which starts on an Epcot Center train, features interviews with farmers throughout the U.S. (including Iowa), overview of agriculture systems, but farming and resulting soil and water damages, and water quality questions raised due to agricultural chemicals. One farmer asks the question, "Is it my fault; my teachers fault or the land grant college's fault?" One farmer from Iowa says we have produced an agriculture system that is productive but not sustainable. One prominent farmer in eastern Nebraska is featured who has reduced his crop production costs, stopped using chemicals, and uses crop rotations. His yields compare to the county average and his profits have increased. "We can have the type of agriculture we want as long as we work within the principles of nature."

65003H 35 Min. FARMING WITH NATURE - 1978

Shows the farming practices of Gene Poirot, a remarkable Missouri farmer who has returned worn-out prairie soil to a fertile soil by giving close attention to soil minerals and natural principles. (The video includes an effective sustainable agriculture message.) He developed his management from observation of principles of nature with 50 some years of experience, much was learned from an area of prairie he left on his farm as an outdoor laboratory. His philosophy is that we need to return to the soil at least a portion of the agricultural products generated from the soil. He uses ponds for livestock watering, irrigation and raising catfish. Ducks, geese, prairie chickens and other wildlife have returned to his farm. He points out that new techniques are adopted only if they maintain long-term land productivity.

75129-1 28 Min. LIFE FORCE: CONCERNING WATER, PART 1, 1984

Verda Williams and Tom Glanville, Iowa State University Extension Service, narrate the video and interview some water resource people in Iowa concerning water quality issues in the state. Both groundwater and surface water quality issues are addressed. Included are scenes from the facts related to: (1) the karst sinkhole region in northeast Iowa, (2) agricultural drainage wells in northcentral Iowa, (3) surface water problems and solutions illustrated in southwest Iowa, (4) the four main aquifers in the State, and (5) the correlation between increased use of agricultural chemicals and the incidence of groundwater contamination. A short segment on the watershed program administered by the U.S. Soil Conservation Service is included to illustrate one program that has been successful in improving municipal water quality at Lamoni, Iowa.

Iowa Citizens for Community Improvement
1607 East Grand Avenue
Des Moines, Iowa 50316
515/266-5213

13 Min. RE-THINKING AG CHEMICALS CONSERVATION WITH IOWA FARMERS

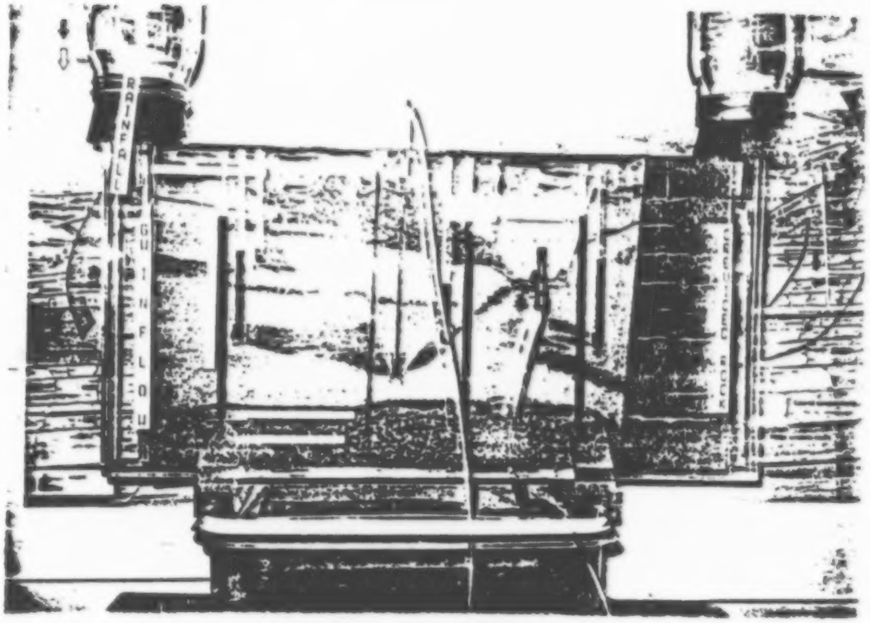
This video examines concerns about agricultural chemicals from the perspective of Iowa farmers. It discusses animal and health problems that can occur, the environmental impact of long term chemical usage, and economic factors associated with reduced chemical farming. It offers some practical ideas that farmers can use to cut their chemical and fertilizer use and promotes a land stewardship perspective.

Soil and Water Conservation Society
7515 N.E. Ankeny Road
Ankeny, Iowa 50021-9764
515/289-2331

30 Min. RIDERS ON THE STORM

The video sets the stage with the message, when the storm produces rain, the water picks up riders (nutrients, pesticides and sediment) as it makes it's way to our streams, lakes and underground aquifers. A high percent of our drinking water comes from groundwater, and groundwater is difficult to cleanup once it's polluted. Farmers from Nebraska are featured. One family who experienced high nitrates in their well resulting in their child developing the "Blue Baby Syndrome" is interviewed. George Hallberg, Iowa Geological Survey Bureau, discusses the unique underground laboratory at the Big Spring trout rearing station in northeast Iowa. This confined aquifer which outlets into the trout pond provides an excellent opportunity to monitor the agriculture activity within the basin area and correlate groundwater quality changes. Hallberg's research shows a direct correlation to increase nitrogen fertilizer use with increased quantities of nitrates found in groundwater. There is some indication that the increase use of chemicals might be correlated to an increase in the development of cancer but we don't know. It will take a long time for research to provide us with the answers, "Can we afford to wait?" A small rural town in Nebraska was included to illustrate that towns are also facing high nitrate problems in their drinking water, requiring costly new deeper wells.

MANUAL
FOR
GROUNDWATER FLOW MODEL



ACKNOWLEDGEMENTS

Groundwater Flow Model designed by Jim Peterson, University of Wisconsin, Extension Environmental Resources Center, Madison, Wisconcin.

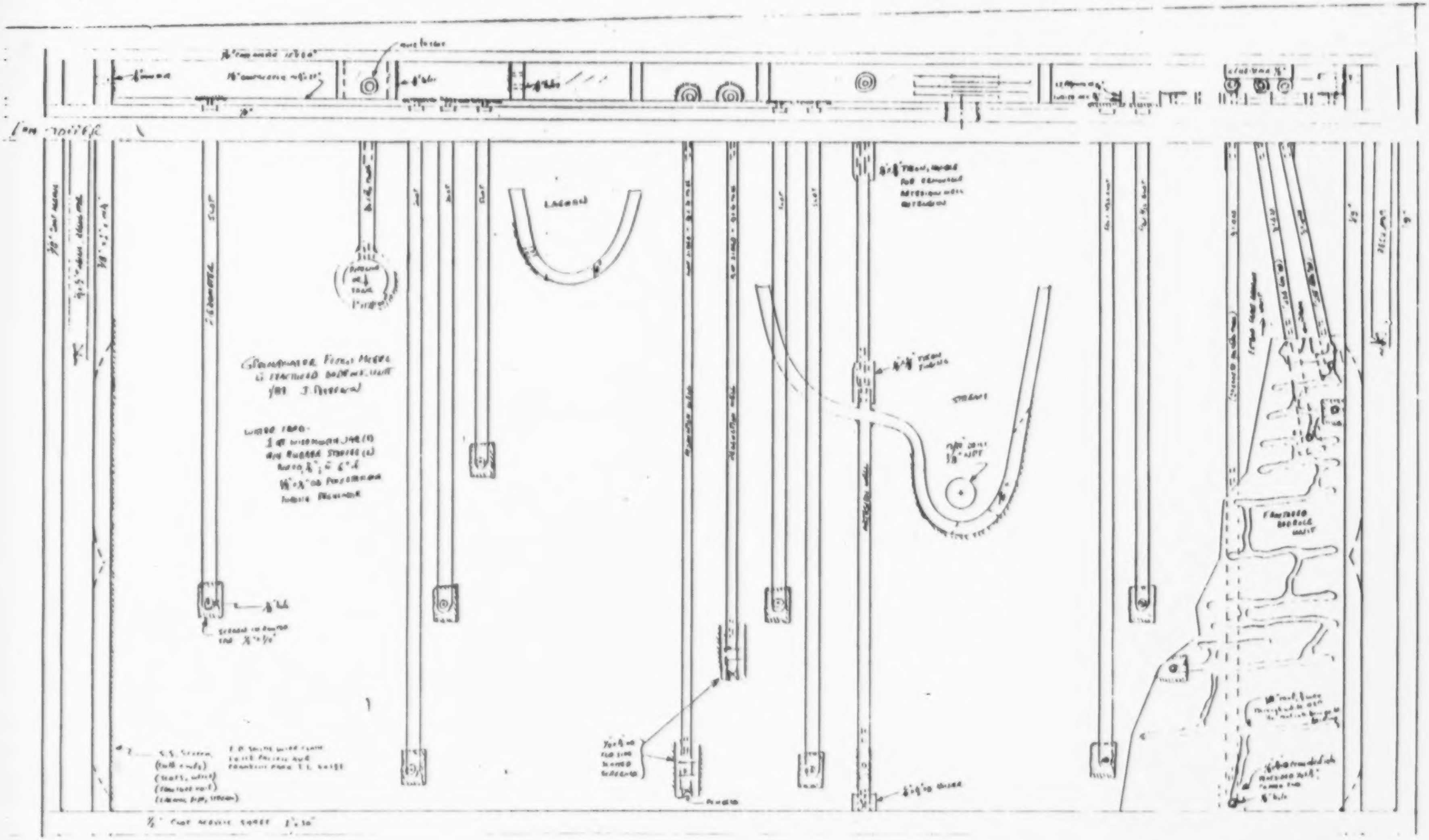
The Flow Model was designed to accompany the "Groundwater Protection Through Prevention" Curriculum For Agricultural Education in Secondary Schools (adapted by Eldon Weber, U.S. Soil Conservation Service - Iowa State University Agricultural Education Department).

The manual was adapted from the Manual For Use of the Sand-Tank Groundwater Flow Model, Central Wisconsin - Stevens Point, College of Natural Resources. Individual contributions made by Jim Peterson, Ron Hennings, Byron Shaw, Earl Spangenberg, and Margy Blanchard.

The models are available from the Iowa State University Student Chapter, Soil and Water Conservation Society, 2521 Agronomy Building, Iowa State University, Ames, IA 50011.

Drawing of a Groundwater Flow Model for the Agricultural Education Curriculum in Secondary Schools

(Designed by Jim Petersen, water quality specialist, Cooperative Extension Service, Madison, Wisconsin)



SUPPLEMENT TO GROUNDWATER FLOW MODEL DEMONSTRATION VIDEO

This manual was written to help you use your Groundwater Flow Model. The manual first gives you a brief introduction to groundwater and its importance. It then provides you with instructions for using and maintaining your model. Finally, it lists concepts that the model can demonstrate, and the mechanics of the demonstration. Suggestions are also given for combining sets of concepts to make presentations.

The level of the information presented in the manual varies from basic to very technical. You may find it helpful to use the manual as a reference book in which you look up topics of interest rather than as a book to be read from cover to cover until you become comfortable with the basic operations of the model.

I. INTRODUCTION

The model is a cut away section of the earth. It shows the make-up of the ground beneath the surface and allows for the demonstration of groundwater principles. Groundwater flow, potential contamination sources and groundwater pollution concepts are demonstrated using different colored dyes.

Water is a vital resource for all living things. It is believed that life originated in water. The bodies of living organisms are mainly composed of water. All living things need water to survive. What properties of water make it unique? The many unique properties of water cause it to have a tremendous impact on our physical environment as well.

Water can dissolve more substances in greater quantities than any other liquid, however this natural ability to dissove and carry materials allows it to be easily contaminated by human activities as well.

People often erroneously believe that groundwater travels hundreds of miles underground. It travels slowly, inches per day, depending on the make-up of aquifer materials.

Groundwater is stored underground in the pore spaces of saturated soil, sand grains, and cracks and fractures in rock. An underground unit of soil, sand, gravel, or fractured rock which can yield a significant quantity of groundwater to wells is called an aquifer. Groundwater flows through interconnected pore spaces in aquifers. Groundwater may flow at different rates in different types of aquifers. As illustrated in the model aquifers are not always uniform either horizontally or vertically, because of differences in composition or in properties. You'll notice in the model, some are fine sand, and some are course sand or gravel.

Aquifers may be separated by layers which do not transmit much water. These layers are called confining layers or aquitards. If a confining layer exists above an aquifer which is fully saturated, this aquifer is then a confined or artesian aquifer. Aquifers without a

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confining layer above them are called unconfined aquifers or water table aquifers.

The groundwater model has two aquifers: an unconfined aquifer of white sand with a small area of gravel included, and a confined artesian aquifer of gravel along the bottom. The aquifers are separated by a confining layer containing clay.

Many people assume that water exists in lakes and rivers beneath the ground. These underground lakes and rivers rarely exist.

You may assume that the water you drink has been underground for thousands of years. In fact, groundwater drawn from shallow wells usually enters the ground within a few miles of the well, and has been in the ground only a few years or tens of years. But, the groundwater that we use today may have traveled through the hydrologic cycle hundreds or thousands of times since the earth was formed.

Groundwater is not new water; it is "recycled" water that is related to all the other water on earth by a process called the hydrologic cycle. The hydrologic cycle describes the inter-relationship of groundwater with surface water, such as lakes and streams, and the water found in the atmosphere, such as clouds, snow and rain. When rain falls on the surface of the ground some of it runs off the land into lakes and streams, this is considered run-off, and some soaks into the ground, which is called infiltration. The water soaking into the ground first goes through an unsaturated zone, some of it being lost to evapotranspiration. Within the unsaturated zone are spaces between the soil particles. Some of these voids are filled with air, and the rest will be filled with the water that soaks in.

Soils in the unsaturated zone are able to hold water in small pores against the force of gravity because of surface tension or cohesion, which is the attraction that water molecules have for one another, and because of adhesion, the attractive forces between the soil particles and the water molecules. Water in larger pores is subject to the force of gravity and is the source of water that moves downward to become groundwater.

Below the unsaturated zone, the water reaches a zone in the sand and gravel where all the cracks and spaces in the soil or rock are filled with water. This is the saturated zone. Water in the saturated zone is groundwater. The top of the saturated zone is called the water table. Dye in piezometers sit at the same elevation of the water table. Piezometers are wells installed to monitor water level and water quality.

Water enters the groundwater system in areas called recharge areas. The amount of groundwater recharge that occurs is related to a number of factors, including the porosity and permeability of the soil, the topography of the land surface, and the amount and timing of the precipitation that occurs.

Timing of rainfall is important. If rain falls at a time when crops are actively growing and using water, very little may make its way to the saturated zone. In fact, in many areas the major recharge periods occur in spring and fall, when precipitation is greater and crops are not actively intercepting and using as much water. Topography influences the rate of groundwater recharge as well. In steep terrains, more water may run off the land into surface water than in flatter terrains.

Groundwater recharge areas are usually located in upland areas. Water then flows "downhill" or "down-gradient" until it reaches an area where it can come to the surface of the ground, called a discharge area. Groundwater discharge areas are normally low areas such as lakes, rivers, and wetlands.

When the outlets to the model are closed, there is no flow through it. When the outlets are open, water can move through the model, because the elevation of the outlet is lower than the inlet elevation. The water table changes as shown by the elevation of dye in each well and as represented by a line that can be drawn with a wax pencil. The dye that moves into the sand or gravel from the piezometers is carried along by the moving water, helping you to see the path and direction of flow. With the outlet open the dye will move up towards the stream, which is down-gradient.

Groundwater is withdrawn from the ground through wells for use in our homes, farms and industries. Wells are drilled or driven into water-bearing underground zones called aquifers. A screen is placed at the bottom of the well to keep soil from being pumped out along with the water. In the case of bedrock wells, there is not always a screen used. A pump is used to withdraw water from the well.

When a well is drilled to penetrate any aquifer, water will enter the well casing. In an unconfined aquifer, the water level will stabilize in the well at the top of the saturated zone, which is called the water table. In a confined aquifer, water in the well will rise above the top of the aquifer, potentially resulting in the flow of water above the surface of the ground, a flowing well or artesian well may result. In the model, you can see the artesian well protruding above the stream. There is a confining layer of clay, 5-10% bentonite clay, above the bottom aquifer of sand which supplies water to the artesian well. The artesian well flows as water tries to move down-gradient.

Groundwater often feeds lakes and streams. You can demonstrate this by closing the stream outlet and observe as the stream slowly fills with water flowing through the ground. The place where groundwater becomes surface water is a discharge area. When groundwater simply bubbles up at the surface of the ground, that discharge area is called a spring. The stream in the model is an example of the interrelationship of groundwater and surface water, where the groundwater enters the stream in the form of a spring.

Groundwater contaminants normally enter the system from the surface, not at points deep within the aquifer as the injection through piezometers might suggest.

Human activities at or near the land surface can contaminate groundwater. As you pour dye into the "leaky lagoon" it will move quickly out of the lagoon through the surface unsaturated zone to the water table. Observe that if you inject enough dye, the "contamination" will move downward in the saturated zone and discharge at the stream outlet. This illustrates that polluted groundwater can be reintroduced to the surface of the ground in the form of spring water. The "leaky lagoon" can represent various sources of groundwater contamination, such as landfills, septic systems, or manure storage areas.

Other human activities which may contaminate groundwater include over fertilization or use of pesticides. In the left portion of the model we have straight sand and the section to the right of it is sand with 1% clay. Grape Kool-Aid is used to demonstrate that some fertilizers and pesticides, if applied in excess or improperly, may leach to the groundwater and some if absorbed to the clay will be held tightly to the soil particles. Different chemicals react differently with different soils. On the left, the purple moves through the sand, showing leaching of groundwater. Where the sand contains clay, the blue component is held tightly by the clay, and the red component leaches to the groundwater. The tightly held blue component attached to clay will not flush out with water. It must be excavated, for demonstration purposes, using a spoon and replaced. One must know the characteristics of soils and chemicals to manage agricultural activities and reduce the potential for groundwater contamination.

There are direct routes of groundwater pollution. Wells or abandoned wells can be contaminated by human activities at or near the land surface. If you pump water from the well with a syringe after filling the leaky lagoon with dye, you'll notice that the well draws water toward it from all directions. It draws the dye traces from the leaky lagoon as well as those from the piezometers on either side. Water being pumped from the well is also red. Since wells create a cone of depression around them as they draw water, they can also draw contaminants toward them from any direction: above, below, or even the area that would normally be considered "downstream."

Another potential direct route of contamination is sinkholes found in the karst topography, limestone regions, primarily found in Northeast Iowa. Water flows down through natural surface openings called sinkholes and cracks developed in fractured bedrock. Agriculture sources of pollution can travel directly from the surface to shallow aquifers which supply well water. The leaky bedrock in the right portion of the model results in a pollution plume that moves upward toward the stream and results in contamination of the adjacent aquifer.

Agricultural drainage wells are another potential direct path of groundwater contamination. Agricultural drainage wells are used in flat topography to serve as an outlet to field drainage systems. They were dug to convert wetlands to agricultural land. Bedrock formations below the wetlands were used to dispose large amounts of drainage water. Agricultural chemicals may be dissolved in surface water and flow into surface inlets connected to agricultural drainage wells which are drilled into shallow aquifers. Agricultural drainage wells serving strictly as outlets to field drainage tile have less chance of direct contamination as the soil over tile lines may filter out some contaminants. However, even with the elimination of surface inlets, chemicals can leach through the soil and be transported through tile to ag drainage wells and the shallow aquifers.

Throughout this introduction, principles of groundwater flow have been discussed. Without a cut away section of the earth represented in the groundwater flow model, it is difficult to visualize groundwater flow and pollution principles. With the demonstrations, it is easier to understand how contaminants travel to and through the earth's surface and realize the serious threat pollution poses to the quality of our groundwater.

If interested in the purchase of a Groundwater Flow Model, contact the Iowa State

University Student Chapter of The Soil and Water Conservation Society, 2521 Agronomy Building, ISU, Ames, IA 50011.

II. MECHANICS OF MODEL USE

This section wil help you set up, use and maintain your groundwater model.

Setup and Demonstration

Allow yourself time to practice and become familiar with the model before demonstrating it.

Use the two plexiglas legs provided to serve as feet for the model. You may also wish to construct a wooden box to transport the model in. This can be inverted and used as a platform to display the model. The model and legs should be placed on top of the water tub with the groove in the bottom of the legs seated over the rib on the ends of the tub lid.

Fill the one-quart bottle with water (represents rainfall). Place the rubber stopper assembly tightly on the bottle. Invert the bottle at the left end of the model so that the water runs into the open channel on the left side. (Later, you can demonstrate additional concepts by adding a second bottle and stopper assembly in the channel on the right side of the model.)

Close the stream outlet.

The level to which the model is filled with water can be regulated by adjusting the length of the tube extending from the rubber stopper.

Make up red and green colored solutions (food coloring). Use 1 part food coloring to 50 parts water for dye. Fill piezometers which extend into the artesian aquifer (deep) with green dye. Fill each of the other piezometers (in shallow aquifers) with red dye. Use the syringe with the long needle which was provided with the model. Add dye until the dye reaches all the way to the bottom of the piezometer and spills out slightly into the soil below. Injecting dye into the pumping wells will allow more points for observation of the water table level. However, the dye will be quickly removed if you pump these wells.

Place the tapered plastic tube provided with the model into the artesian well outlet in the lake. Add green dye to the water which rises in this tube for easier observation of the water level.

Lower the tubing connected to the outlet to let out the water in the water tub.

Continue to refill the inlet bottles as needed. You will begin to observe movement of dye from the injection wells and from the excess added to the piezometers toward the outlet. If you add excess dye to the piezometers periodically, you will have a continuous dye trace to the outlet. If you do not, you will have only a single spot to follow as it moves away from its source toward the outlet.

Flow rates will vary depending on the materials available at the time each model was

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constructed. Practicing beforehand will allow you to plan your demonstration around the rate of movement observed in your individual model.

Cleanup of Model After Use

When you finish your demonstration, the dye should be flushed out of the model within 24 hours. Run 3-4 bottles of clean water through the model. Any faint dye traces which remain will not harm the model, but they might interfere with visualization of the dye traces in the next demonstration. Drain the lake by opening the lake outlet before putting the model into storage. If you wish, you may siphon out the remaining water.

It is not necessary to remove the dye from the piezometers before storing the model. If you do wish to remove the dye, place a piece of masking tape over the piezometer openings on top of the model. Wrap the small syringe needle with tape for a better seal, push it through the tape, and withdraw the dye from the piezometers. Remove the tape before storing the model. Another method is to force clean water into the piezometers with the syringe, displacing the dye.

Long Term Maintenance of Model

After a period of time you may find decreased yield from the pumping wells caused by bacterial or algal growth plugging the well screens. Run a chlorine bleach solution of approximately 1 tablespoon/quart of water through the model to solve this problem. Also inject this solution into each well or piezometer. Allow the model to sit for an hour or more. Follow this with 3-4 bottles of clean water. Withdraw several volumes of clean water from each well or piezometer to thoroughly rinse it.

The area in the sand aquifer below the gravel wedge may build up concentrations of dye because of preferential movement through the gravel wedge. You may be able to insert a thin strip of stiff plastic, such as a ruler, in the channel to temporarily close off flow to the gravel wedge and force more dye to go through that area of the sand aquifer.

If you have dye accumulating in the model, you may be tempted to use a bleach solution to clear it. However, remember that the presence of these dye areas is an indication that water does not move through that area very readily. If you add bleach, it will be just as difficult to flush the bleach through as it was to flush the dye through. Any new dye that you add will then be decolorized by the bleach remaining in that area of the model.

If the outlets leak around the threads, they can be repaired by wrapping teflon pipe tape around the threads.

Never allow the model to freeze.

Concepts that can be demonstrated using the model.

These are examples of basic groundwater concepts you can demonstrate using the model. You will probably discover many others as you use the model yourself.

1. Concept: Groundwater often comes from nearby sources.

   Action: Fill the one quart widemouth bottle with water and invert it at the left end.

   Discussion: People often erroneously believe that groundwater travels hundreds of miles underground. They may also believe that the water they drink has been underground for thousands of years. In fact, groundwater drawn from shallow wells in Wisconsin usually enters the ground within a few miles of the well, and has been in the ground only a few years or tens of years.

2. Concept: Groundwater is contained underground in the spaces between sand grains and other soil particles, or in cracks and fractures in rocks.

   Action: Allow water to run through the model.

   Discussion: Underground lakes and rivers rarely exist. Notice that the water entering the model at the left side saturates the sand and gravel and exits at the right, but there are no observable rivers or channels through which it flows.

3. Concept: Groundwater flows from upland areas to low areas, or from areas of high hydraulic head to areas of lower hydraulic head.

   Action: Allow water to run through the model. Add dye to the seven piezometers (see diagram for help) until it moves out of the piezometers into the soil below.

   Discussion: Water enters the groundwater system in areas called recharge areas. It then flows "downhill" until it reaches an area where it can come to the surface of the ground, called a discharge area. When the outlets to the model are closed, there is no flow through it. When either of the outlets are open, water can move through the model, because the elevation of the outlet is lower than the inlet elevation. The dye that moves into the sand or gravel from the piezometers is carried along by the moving water, helping you to see the path and direction of flow.

4. Concept: Groundwater is withdrawn from the ground through wells for use in our homes, farms and industries.

   Action: Look at the two pumping wells
   Use a syringe to pump water from the wells.

   Discussion: Wells are drilled or driven into water-bearing underground zones (aquifers). A screen is placed at the bottom of the well to keep soil from being pumped out along with the water. (Bedrock wells do not always have screens.) A pump is used to withdraw water from the well. Municipal water systems usually have one or more wells, a water tower or ground level reservoir for storage, and a distribution system of underground pipes which carries water to the individual homes.

5. Concept: Groundwater is related to surface water and to all other forms of water found on earth through the hydrologic cycle.

   Action: Close the lake outlet so that the lake fills with water. Open the outlet.

   Discussion: The hydrologic cycle describes the interrelationship of groundwater with surface water, such as lakes and streams, and the water found in the atmosphere, such as clouds, snow and rain. Groundwater often feeds lakes and streams. The place where groundwater becomes surface water is a discharge area. When groundwater simply bubbles up at the surface of the ground, that discharge area is called a spring. The lake in the model is an example of the interrelationship of groundwater and surface water.

6. Concept: The underground units of soil and rock which can yield water to wells are called aquifers. Aquifers are not always uniform either horizontally or vertically. Aquifers may be separated by layers which do not hold or transmit much water. These layers are called confining layers or aquitards.

   Action: Look at the sand and gravel layers in the model.

Discussion: The white sand aquifer in the model has a layer of coarse gravel included within it. Below the white sand layer is a layer of material containing clay. This layer allows very little water to pass through it, so it acts as a confining layer. Below the confining layer, there is a second aquifer of coarse gravel. There is little interconnection between these two aquifers. If you pump the well in the upper aquifer, you will see that the piezometers in that aquifer show a drop in water levels, while those in the lower aquifer show little response. Similarly, pumping the well in the lower aquifer causes little response in the upper piezometers.

7. Concept: The soil and rock below the earth's surface normally consists of both a saturated and an unsaturated zone. The top of the saturated zone is called the water table. A type of monitoring well called a piezometer can be used to define the top of the saturated zone.

Action: Allow water to run through the model. Add dye to the seven piezometers.

Discussion: Notice that the end of the tube where water drips out of the bottle (the inlet) is higher above the surface of the table than is the plastic elbow where the water flows out of the model (the outlet). As water flows from the inlet to the outlet, a slope is created on the water table.

Use a water soluble pen or wax pencil to connect the water levels in each of the piezometers in the upper aquifer. You have now drawn in the water table. Note that it slopes from the inlet downward toward the outlet.

If you wish, you may add a small block under the left end of the model. This will cause the difference in height between the inlet and the outlet to increase, creating a larger and more obvious slope on the water table. Other methods of changing the slope of the water table include raising or lowering the inlet tube in the stopper, or changing the extent to which the outlet elbow is opened.

8. Concept: Piezometers are a type of monitoring well. They differ from drinking water wells in their construction and use.

Action: Look at the piezometers and drinking water wells in the model.

Discussion: Piezometers are usually installed by researchers studying groundwater in an area. Since groundwater flows from high areas to low areas, knowing the height of water in a number of piezometers (relative to mean sea level) can allow you to map the direction of groundwater flow. Piezometers are designed to be open only at a single point in the aquifer. They usually can have water samples drawn from them. However, since they are not intended to be permanent sources of water, they are often not as large or as durably constructed as drinking water wells.

The construction of drinking water wells is normally regulated by state codes which specify the depth required and the materials used in construction. They must be carefully located away from sources of contamination, unlike piezometers, which are often intended to collect contaminated water. Existing drinking water wells can sometimes be used as monitoring wells by researchers if exact details of their construction and depth are known.

9. Concept: Water in artesian aquifers is under pressure. This pressure causes the water level in wells penetrating the artesian aquifer to rise above the top of the aquifer.

Discussion: The artesian aquifer in the model is under pressure because the confining layer of sandy clay above it significantly retards water movement upward. Also, this aquifer has a recharge area on the left, but no obvious discharge area. If the confining layer was totally impermeable, there would be no flow in the artesian aquifer at this time. However, in the model and in nature, confining layers usually leak. The pressure in the aquifer allows water to move upward through the confining layer. If dye is injected into the artesian aquifer through the injection well, this upward flow may be observed as dye streaks upward in the sand above the confining layer after about 20 minutes.

10. Concept: The potentiometric surface is the level to which water will rise in a well penetrating a confined aquifer.

Action: Observe the water levels as defined by dye levels in the seven piezometers.

Discussion: The white sand aquifer is an unconfined aquifer because it has no confining layer above it. The level to which water rises in a well in an unconfined aquifer is the water table. In the confined artesian gravel aquifer, the potentiometric surface is above the top of the aquifer, and is actually above the water table in the overlying unconfined aquifer.

11. Concept: When the potentiometric surface of an aquifer is above the surface of the ground, a flowing well or spring may result.

Action: Look at the small tapered tube in the artesian outlet in the lake. Notice that the water level in the tube is above the lake level. (Adding dye to the tube may help you to see this better.) Now remove the tube and close the lake outlet. Notice that water flows from this opening, and the lake level begins to rise. Also, observe that there is a slight lowering of the water level in piezometer since the opening of an outlet for the artesian aquifer reduces the hydraulic pressure caused by the inlet elevation.

Discussion: There are several types of springs that occur in nature, but the most common type of spring is a spot where the water table of an unconfined aquifer intersects the land surface. Such springs often occur in the bottoms and sides of lakes and rivers. Sometimes they appear at the surface of dry land and become the headwaters of a stream. The spring in the model is the result of penetration into and discharge from the artesian aquifer. It is more correctly thought of as a flowing well.

People sometimes believe that springs have mysterious health-giving properties, and that any water coming from a spring must be pure. However, since the water in springs is simply water that is moving through the hydrologic cycle, it can be affected by any groundwater pollution source that contaminates the aquifer supplying the spring.

12. Concept: The texture of the materials in an aquifer affects the rate of flow through the aquifer.

Action: Notice that the water feeding the model enters along the entire vertical channel at either end. Inject dye into the three injection wells at the left end of the model (see the diagram for help). Notice that the dye injected into the coarse gravel wedge at the left of the model disperses much faster than the dye injected into the white sand. The dye movement out of the gravel wedge will radiate out in all directions.

Discussion: Both the coarse gravel wedge and the white sand aquifer are well-sorted, which means that the grains of gravel or sand are all roughly the same size within each unit. Water can move through well-sorted gravel faster than well-sorted sand because larger grain size leads to larger pore size, and larger pore size leads to less surface area in contact with the moving water. The smaller the surface area the water contacts, the less frictional resistance there will be in the moving water. The lower frictional resistance leads to a greater velocity of groundwater flow. The gravel can then be said to have a higher intrinsic permeability, and as a result, a higher hydraulic conductivity.

Water flowing through an aquifer will take the path of least resistance. Since the resistance to flow is lower, more of the water entering the model per unit area will enter into the gravel wedge than into the sand layer around it. However, all this water entering into the gravel must have a way to exit. A hydraulic pressure is created which allows the water to exit even in an upward direction into the sand above the gravel wedge. In other words, the unconfined sand aquifer becomes a confining layer for the gravel wedge, creating artesian conditions in the gravel. In this case downgradient is actually upward. The dye movement should illustrate this.

You will also notice that the dye spot injected into the injection well in the sand aquifer moves more slowly than the dye spots that come from piezometers   , indicating that less water per unit area moves through this area of the model because of preferential movement through the gravel.

13. Concept: Water flows into rivers from many directions.

Discussion: Rivers are natural discharge areas for groundwater. In the model, you will observe dye traces moving from all directions toward the river and then entering into the river when the river outlet is open.

14. Concept: Pumping wells draws water toward them from all directions. The water table gradually becomes lower around a well in an unconfined aquifer as water is withdrawn from the ground. The unsaturated zone (the zone which has been dewatered) around the well is called the cone of depression or drawdown cone.

Discussion: Pumping the well causes a zone around it to become unsaturated. This unsaturated zone is called a cone of depression. The slope of the water table from the water level in the pumping well to surrounding areas is much greater than the normal slope of the water table, so water can move toward the well much faster than it normally would. The cone of depression is three-dimensional, so water can be drawn toward the well from any direction, even the direction that we would normally consider to be "downstream". If you vary the pumping rate on the syringe, you can observe changes in the size and shape of the cone of depression by observing the changes in the water level in surrounding piezometers and the change in the rate at which dye traces are drawn toward the well.

The source of water drawn from pumping well   is basically gravity drainage of water stored in the aquifer. However, the source of water drawn from pumping well 1 in the artesian aquifer is quite different. The artesian aquifer yields water mainly because reduction in pressure in the aquifer as water is withdrawn leads to expansion of the water in the aquifer and compaction and settling of the aquifer materials. Cones of depression in confined aquifers are usually not as deep, but are more areally extensive than those in unconfined aquifers.

15. Concept: Drawing water from a well can interfere with the ability of neighboring wells to produce adequate water.

Action: Pump well with the syringe at a very rapid rate.

Discussion: If well is pumped rapidly enough, the water level in the aquifer will drop below the level of piezometers so that these piezometers no longer contain any water. A high-capacity well may be able to lower the water table enough so that shallow wells nearby will fall within the cone of depression and will produce little or no water while the high-capacity well is being pumped. This is called well interference.

16. Concept: Human activities at or near the land surface can contaminate groundwater.

Action: Pour dye into the "leaky lagoon" to a level above the holes drilled in the sides of the lagoon. If the lagoon does not leak, help it by inserting the needle of the syringe through the holes in the lagoon into the gravel below.

Discussion: Dye should quickly move out of the lagoon through the surface unsaturated zone to the water table. Observe that this "contamination" moves downward in the saturated zone and discharges either at the lake outlet or the outlet on the right side. The "leaky lagoon" can represent various sources of groundwater contamination, such as landfills, septic systems, or manure storage areas.

17. Concept: Wells can be contaminated by human activities at or near the land surface.

Action: Pump water from well 2 with a syringe after filling the leaky lagoon with dye. Notice that well 2 draws water toward it from all directions. It draws the dye traces from the leaky lagoon as well as those from the piezometers on either side. If you have added red dye to the lagoon, observe that the water being pumped from well 2 is also red.

Discussion: Since wells create a cone of depression around them as they draw water, they can also draw contaminants toward them from any direction: above, below, or even the area that would normally be considered "downstream."

18. Concept: Pollutants travel with the groundwater, but they may travel at different rates.

Action: Observe that the plumes of green dye which you have injected at various points in the model have separated into blue and yellow areas.

Discussion: Groundwater can carry pollutants that it has picked up as it flows through the system. However, some chemicals move faster than others in groundwater. The soil particles that make up an aquifer may weakly adsorb some chemicals, slowing their flow rate. Others are more soluble and move through more rapidly. These soluble chemicals are good indicator chemicals to test for in drinking water. They can tell us that a pathway exists between a source of contamination and a drinking water well. Other chemicals associated with that source may also move down that pathway, although perhaps not as quickly or in as great a concentration.

19. Concept: Contaminated groundwater may pollute surface water.

Action: Notice that the water collecting in the lake is not clear. It has been affected by the dye that has been injected at various points.

Discussion: Surface water bodies such as lakes and rivers have two major sources of water: surface runoff from rainfall and snowmelt, and groundwater flow, called baseflow. Baseflow is the reason that streams flow even during dry spells. In addition, since the temperature of groundwater is about 50 degrees F year-round, baseflow allows streams to flow in winter even when the ground is frozen. Any contaminants in groundwater can then be discharged into surface water. In many ways, surface water is better able to treat contaminants than groundwater is. Natural processes such as sunlight, aeration, and turbulance break down some pollutants. However, other pollutants from groundwater, such as nutrients, can cause algae blooms, weed problems, and turbidity in surface waters.

20. Concept: Contaminated surface water can pollute groundwater.

Action: Pump well 2 steadily with a syringe until you see dye being drawn toward it from the river.

Discussion: If the cone of depression created by pumping well

2 extends all the way to the river, the river can actually recharge the groundwater. This occurs in some municipal wells and irrigation wells located in sandy aquifers near river systems. The filtering action of the sand removes most microorganisms, but chemical contamination can enter the aquifer in this way.

21. Concept: Groundwater is recharged by precipitation and snowmelt.

Action: Use a sprinkling device to add water along the surface of the model.

Discussion: Recharge of the aquifer from above creates additional head that pushes dye plumes near the surface deeper into the aquifer. The dye plumes created by recharge of the model in this way are most representative of natural conditions. Groundwater contaminants normally enter the system from the surface, not at discreet points deep within the aquifer as the injection through piezometers might suggest.

22. Concept: Capillary action can cause upward movement of water and contaminants above the surface of the water table.

Action: Observe that most of the dye you have added to the leaky lagoon has moved downward and to the right. However, some has moved upward into the gravel layer, above the potentiometric surface.

Discussion: Capillarity is a phenomenon that explains the upward movement of water above the surface of the water table. Water is attracted to and adheres to surfaces of solid materials. In addition, cohesive forces (also called hydrogen bonding) bind water molecules to each other. This allows water to move upward in small pores above a saturated layer. The pore spaces in the sandy and gravelly materials are small enough to act as capillary tubes. The smaller the size of the pores, the higher the water will rise in them. Because soil pores are not straight uniform openings, capillary rise in natural soils is less than in similar sized glass tubes.

23. Concept: Water quality can vary within an aquifer.

Action: Observe that dye spots, when they first enter the aquifer, occur only in a narrow zone. As the dye plumes move downgradient, they become wider.

Discussion: Contaminants entering an aquifer often do so only at a point or in a narrow zone. The concentration of the contaminant may be quite high in that small volume of water. Often the contaminant is concentrated near the top of the water table. However, as groundwater continues to move, the zone of contamination widens out.
Contaminant transport, or the movement of contaminants in the groundwater system, is composed of a number of factors:
Advection is the process by which contaminants are transported by the motion of flowing groundwater.
Dispersion is the process by which contaminants follow a variety of distinct flow paths through the porous medium (the aquifer) and become more mixed.
Reactions may occur which weakly adsorb contaminants, causing them to move at a slower rate than the water in the aquifer.
The net effect of these processes is dilution - as the plume moves along and widens, a greater volume of water is mixed with the same quantity of contaminants.

It is also useful to note that if recharge were induced by sprinkling water over the top of the entire model, the dye traces would angle downward and widen as they moved across the model. This method of recharge would more closely simulate natural conditions.

24. Concept: Confining layers that separate aquifers usually leak.

Action: Pump water from well 1 using a syringe. Notice that the water levels in piezometers A and E, which extend into the artesian layer, drop rapidly. The water levels in piezometers B, C, and D are relatively stable, since a confining layer separates the two aquifers. However, also notice that dye begins to move downward in the sand aquifer toward the confining layer.

Discussion: Most of the recharge in the gravel artesian aquifer occurs on the left side. The gravel aquifer is able to yield large volumes of water and recharge itself quite rapidly. However, when water is withdrawn from the artesian aquifer, a zone of lower pressure is created which induces water movement downward through the confining layer. Water moves through the confining layer very slowly, carrying dye with it and showing that the confining layer is not the totally impermeable barrier to flow that it might appear to be. In addition, most naturally occurring confining layers vary in thickness and may be fractured or discontinuous. The presence of a confining layer below is not always sufficient to protect a valuable aquifer below from contamination if a large waste source is placed above it.

25. Concept: Wells can cause groundwater pollution.

Action: Inject dye into the seven piezometers or into the two pumping wells using a syringe. Fill them until the solution reaches all the way to the bottom and begins to spill out below.

Discussion: Wells with defects such as cracked or rusted casings or wells not properly sealed at the surface can serve as conduits for contaminated surface water to enter the groundwater. Wells should be protected from damage while they are being used, and should be properly sealed when they are to be permanently abandoned. Wells should never be used to dispose of unwanted materials. State and county governments have codes regulating the proper construction, maintenance and abandonment of wells.

26. Concept: Sources of groundwater contamination may be continuous or intermittant.

Action: Observe that in operating the model, you need to add dye solutions to the piezometers periodically if you want a continuous dye trace. A single addition of dye at the beginning of the demonstration results in only a single spot of dye to follow.

Discussion: Some sources of contamination may occur as a single slug, such as a spill. These will eventually move through and be flushed out of the groundwater system. The time period required may be from days to years. Other contamination source may input contaminants continuously, such as a wastewater treatment lagoon, septic system, or landfill. As these are flushed out of the groundwater system, additional contaminants from the source will move in to replace them.

27. Concept: Once groundwater becomes contaminated, the contamination may persist for long periods of time and over long distances.

Action: Observe that the dye is eventually flushed out of the model.

Discussion: Unlike our model, the environment is not easily able to eliminate pollutants. Contaminants in groundwater may move only a few feet each year, meaning that they will remain in groundwater for many years. Eventually, the contaminants that are not chemically or biologically modified will reach a discharge zone. The contaminated groundwater that discharges into rivers, if not removed by natural treatment processes, eventually makes its way to the ocean.

28. Concept: Groundwater flow lines have curved paths.

Action: Observe dye traces that extend from the recharge area to the discharge area. Notice that they travel in a nearly straight line across the model and then curve upward at the discharge area.

Discussion: Recall that the force potential, or the driving energy behind groundwater flow, is made up of two energy components: the pressure head and the elevation head. Recall also that groundwater moves from areas of high total head to areas of lower total head. At the recharge area of the model, the sum of the energy forces causes water and dye to move in a downward direction. At the discharge area, the pressure head and the total head become lower, since water is being removed from the system at that point. Although water is moving "uphill", it is actually moving from an area of higher total head to an area of lower total head.

Suggested presentations using the model.

These are some suggestions for how concepts can be combined to make a unified presentation using the model. At first, you may find it difficult to organize your presentation, so my suggestions will help you get started. Later, with practice and familiarity with using the model, you will discover your own "favorite presentation", specially tailored to the audience you are presenting the information to.

1. General information about groundwater.

    C1. Groundwater often comes from nearby sources.
    C2. Groundwater is contained in pore spaces and cracks.
    C3. Groundwater flows from high head to low head.
    C4. Groundwater can be withdrawn from wells.
    C5. Groundwater is part of the hydrologic cycle.
    C21. Groundwater is recharged by precipitation.
    C16. Human activities can contaminate groundwater.
    C17. Wells can be contaminated by human activities.

2. Water quality.

    C23. Water quality can vary within an aquifer.
    C26. Contamination may be continuous or intermittant.
    C18. Pollutants travel with the groundwater.
    C25. Wells can cause groundwater pollution.
    C19. Contaminated groundwater can pollute surface water.
    C20. Contaminated surface water can pollute groundwater.

3. Properties of aquifers.

    C6. Definition of aquifers.
    C7. Definition of water table.
    C10. Definition of potentiometric surface
    C9. Definition of artesian aquifers.
    C11. Springs may originate in artesian aquifers.
    C24. Confining layers usually leak.
    C12. Texture of the aquifer materials affects flow rate.
    C22. Capillary action may cause upward movement of water.

4. Characteristics of water wells.

    C4. Groundwater can be withdrawn from wells.
    C8. Piezometers and drinking water wells may differ.
    C10. Definition of potentiometric surface.
    C11. Flowing wells may result from artesian aquifers.
    C14. Definition of cone of depression.
    C15. Wells may interfere with each other.
    C17. Wells can be contaminated by human activities.
    C25. Wells can cause groundwater pollution.

5. Interrelationship of groundwater and surface water.

C5. Groundwater is part of the hydrologic cycle.
C13. Water flows into rivers from many directions.
C19. Contaminated groundwater can pollute surface water.
C20. Contaminated surface water can pollute groundwater.
C11. Springs may result from artesian aquifers.

APPENDIX A

USING A PUMP TO SUPPLY WATER FOR LARGE SAND-TANK GROUNDWATER FLOW MODEL

The sand-tank groundwater flow models are convenient teaching tools because of their "low-tech" operating requirements. However, people have expressed interest in operating the models continuously with a pump. These directions were developed by Margy Blanchard for use with a larger version of the model. They are included here for your reference if you would like to attempt to use a pump to operate your model.

1. Put 6 or 7 gallons of water in a large trash can.

2. Put pump in trash can.

3. Put water supply hoses from pump into open spaces on each side of the top of the model.

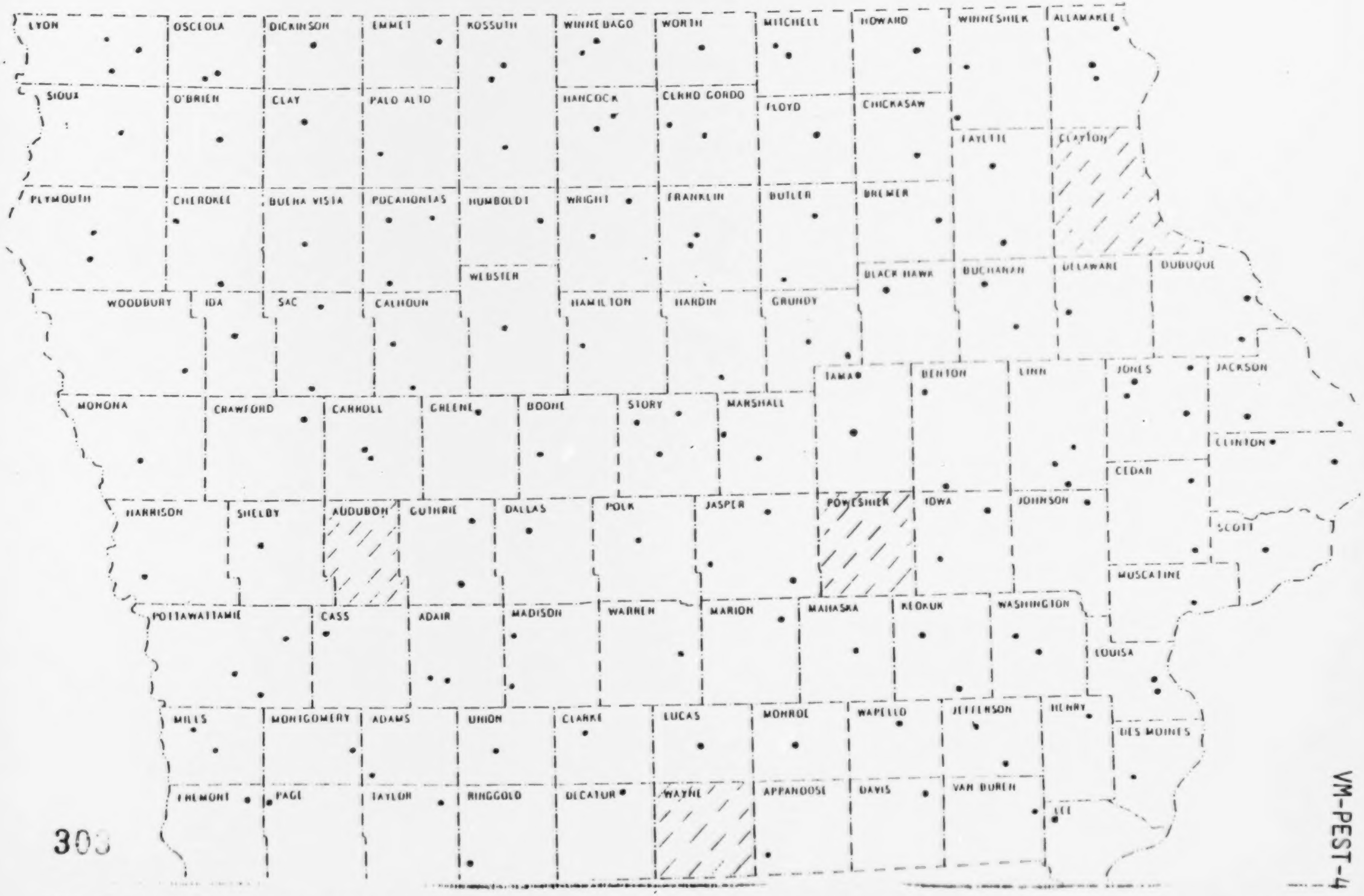
4. Attach overflow hoses to bottom end of outlet fitting on each side of the model. Put end of both overflow hoses in trash can. BE SURE THAT OVERFLOW HOSES ARE NOT KINKED and that water flows smoothly into the trash can. (Note that the small model only has an outlet fitting on one side.)

5. Put container under river discharge to catch water.

6. Turn pump on.

7. Watch the model fill with water. Be sure that water is going where you want it to.

1989 RESOURCEFUL FARMING DEMONSTRATIONS


LYON
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Adams	Wayne D. Scott R R 1, Box 117, Nodaway, IA 50857 (712-785-3789)
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Allamakee	Bernard J. Welsh R R 2, Waukon, IA 52172 (319-568-2820)
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Story	Lauren Twedt R R 1, Box 146, Roland, IA 50236 (515-388-4580)
Story	Pete Wauson R R 1, Nevada, IA 50201 (515-382-6254)
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Tama	John (Jack) Schoup R R 2, Box 95, Reinbeck, IA 50669 (319-345-2040)
Taylor	Steven Basler R R 2, Sharpsburg, IA 50862 (515-349-8551)
Union	Ron Dunphy R R 2, Box 155, Creston, IA 50801 (515-782-4327)
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Wapello	Ed Klodt R R 5, Ottumwa, IA 52501 (515-684-8961)
Warren	Merrill & Marilea Chase, Chase Farms Ltd. 2045 Kirkwood St., Milo, IA 50166 (515-942-6903)
Washington	Rob Stout R R 2, Box 158, Keota, IA 52248 (319-698-2722)

Washington	Tom Vittetoe R R 2, Box 93, Washington, IA 52353 (319-653-2529)
Webster	Gregg Hora 2915 - 15th Avenue NE, Fort Dodge, IA 50501 (515-573-8375)
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Winneshiek	Kenneth Kriener R R 2, Waucoma, IA 52171 (319-776-4521)
Winneshiek	Dave McConnell R R 5, Box 78, Decorah, IA 52101 (319-382-9218)
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Worth	John Janssen R R 2, Box 180, Northwood, IA 50459 (515-324-2618)
Wright	Dale Arends R R 1, Box 171A, Belmond, IA 50421 (515-853-2338)
Wright	George Disney R R 2, Box 16, Clarion, IA 50525 (515-532-2051)